

F.O. 511 Copy Right, 1976
 F.O. 512 Copy Right, 1976
 First Revision, F.O. 560 Copy Right, June, 1977
 Second Revision, F.O. 560-1 Copy Right, June, 1978
 Third Revision, F.O. 560-2 Copy Right, January 1, 1980
 — Bally Manufacturing Corporation All Rights Reserved —

F.O. 560-2 supercedes and replaces all previous publications above and includes repair procedures of all models of current and past Bally games.

The original MPU module, AS-2518-17, can be converted for use and games. With games the electronic sound capability, should this ever become necessary, the procedure is making this change is detailed in F.O. 597, which is part of kit #523. This kit is available through your local Bally Distributor.

The AID kit refers for service, the original and the new MPU module is kit #485-1. Figure A4-2 details the conversion of kit #485 to the kit #485-1 status. The change is simple, it allows testing of the A14 address line not used on the original MPU module AS-2518-17.

For service personnel wishing to obtain an AID kit, #485, is available through any Bally Distributor.

MASTER INDEX

PAGE	
2	PART I, MODULE REPLACEMENT INDEX
21	PART II, COMPONENT REPLACEMENT INDEX

PART I

MODULE REPLACEMENT INDEX

PAGE	
3	I INTRODUCTION TO REPAIR PROCEDURE
3	II DESCRIPTION OF SELF DIAGNOSTIC TEST
6	III DESCRIPTION OF AID PROGRAM
8	IV RECOMMENDED GENERAL PRACTICES
	V DIAGNOSTIC TABLES
8	A) MPU MODULE, A4
9	B) LAMP DRIVER MODULE, A5
12	C) DISPLAY DRIVER MODULE, A1
14	D) SOLENOID DRIVER MODULE, A3
16	E) SWITCH MATRIX
16	F) VOLTAGE REGULATOR (P/O A3)
18	G) POWER TRANSFORMER MODULE, A2
20	H) SOUND MODULE, A8

LIST OF FIGURES

4	FIGURE I ELECTRONIC PINBALL MACHINE
5	FIGURE II BLOCK DIAGRAM — ELECTRONIC PINBALL GAME
7	FIGURE III SELF-(DIAGNOSTIC) TEST PROCEDURE
6	FIGURE IV USE OF AID, PROBE IN FAULT LOCALIZATION
10	FIGURE V USE OF GROUNDING LEAD IN FAULT LOCALIZATION
20	FIGURE VI POWER DISTRIBUTION DIAGRAM

AID, BALLY KIT #485-1, IS REQUIRED FOR USE WITH THIS PROCEDURE.
SEE PAGE 27 FOR CONVERSION OF AID KIT #485 TO AID KIT #485-1

FOR COMPONENT REPLACEMENT INDEX, SEE PAGE 21.

REFERENCES

- 1) F.O. 601, THEORY OF OPERATION, BALLY ELECTRONIC PINBALL GAMES.
- 2) M6800 MICROCOMPUTER SYSTEM DESIGN DATA MANUAL
MOTOROLA PRODUCTS, INC.
BOX 20912
PHOENIX, ARIZONA 85036

I. INTRODUCTION

Repair of the electronic game in the game room is by module replacement or cable harness repair. See Figures I and II. The procedures herein facilitate fault localization to the defective lead or module. The game is restored to operating condition by cable repair or by the substitution of a known, good module. Defective modules are returned to a repair station for corrective action.

The repair procedures take advantage of two special test routines designed into the game. The first routine causes the MPU (microprocessor unit) module to examine itself for proper operation on power-up. If the MPU module determines that it is correct, the power-up tune announces that the game is operational. If the MPU module determines that it is not correct, it will not allow game play. The second routine is the Self-(Diagnostic) Test. This routine causes the MPU to exercise each of the other electronic modules. Burned out lamps, defective display modules, solenoids and stuck switches are all quickly located by means of this routine.

A small module, called AID1, is especially useful in determining continuity between modules under actual digital operating conditions. AID1 is a small plug-in module that mates with J5 on the MPU module. The module is available from the Bally Service Department as part of Kit #485-1.

No special tools or equipment are required by the repair procedure. The AID kit, a volt/ohmmeter, Simpson model 260 (20,000 Ohm/VDC) or equivalent and several test lead jumpers are necessary. The standard tool box complement of soldering iron and tools are also required for making cabling and electromechanical component repairs. Schematics are helpful, and are required as an aid to troubleshooting. A schematic for each module and a three sheet wiring diagram are included with each game.

II. DESCRIPTION OF SELF-(DIAGNOSTIC) TESTS

At power on, the LED on the MPU module flashes once. After a pause, it flashes six more times and goes out. A power-up tune is played to announce game readiness. This indicates proper MPU operation condition and successful completion of the power-up test. If this does not occur, refer to the MPU Diagnostic Table, Section VA, Page 8.

- 1) Pressing the self-test button* inside the door initiates the self-test routine. See Figure III. All switched lamps flash off and on continuously. In case of improper operation, (lamps off, or always on), refer to Lamp Driver Diagnostic Table, Section VB, Page 9.
- 2) Pressing the self-test button again causes each digit on each display to cycle from 0 thru 9, all off, and repeat continuously. Improper operation consists of displays, digits or segments always on or always off. If improper, refer to Display Driver Diagnostic Table, Section VC, Page 12.
- 3) Pressing the self-test button again causes each solenoid to be energized, one at a time, in a continuous sequence. Hold both flipper buttons 'in' during this test. The number appearing on the Player Score displays are the same as the number assigned to the solenoid. The sound of a solenoid pulling-in as a number appears indicates proper operation. The absence of sound is improper. If improper, note the solenoid number and refer to the Solenoid Driver/Voltage Regulator Module Diagnostic Table, Section VD, Page 14. The Solenoid Assembly Identification Table, stapled in the back box, identifies the Solenoid by showing the assigned number and description.

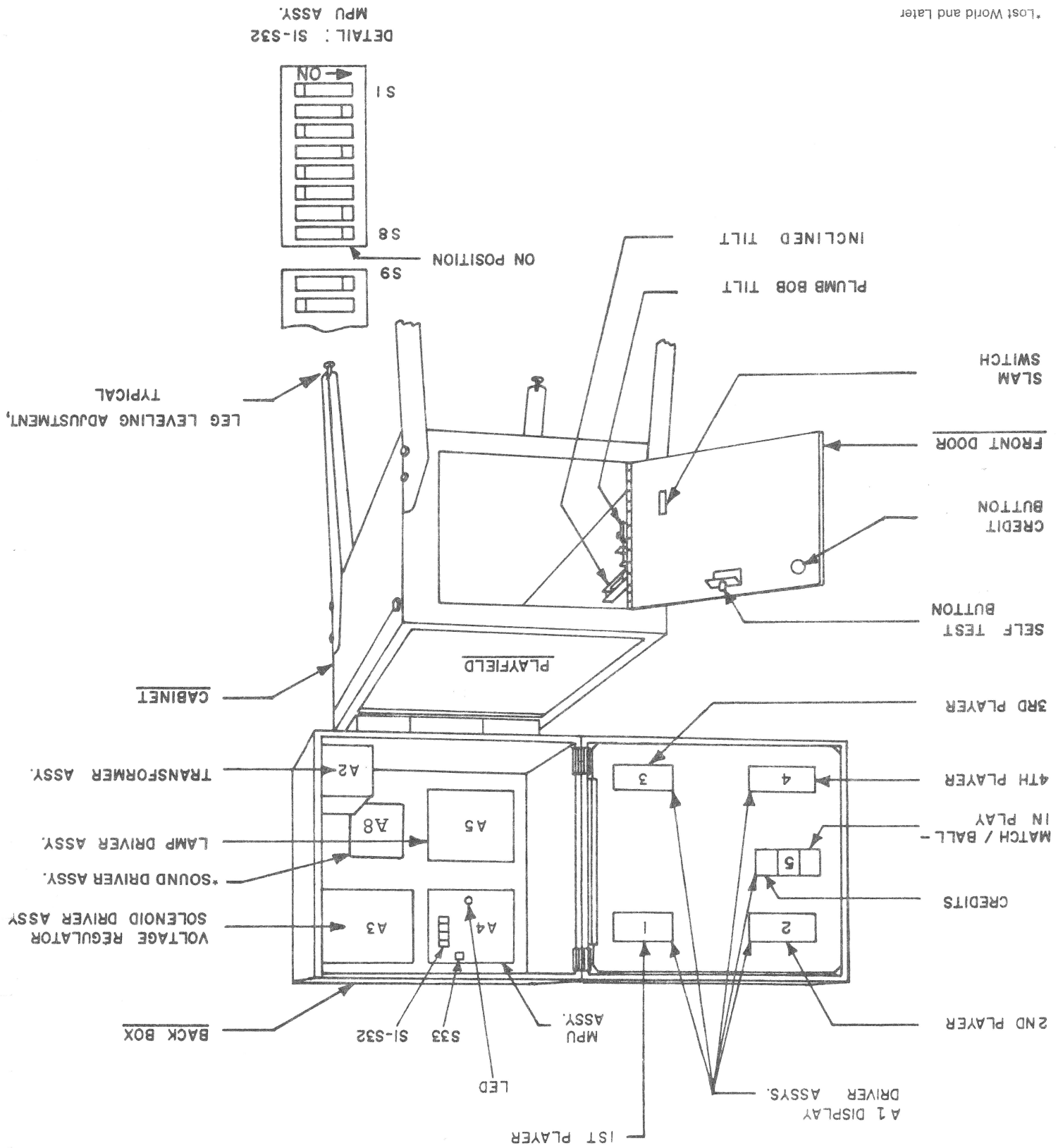
- 4)** Pressing the self-test button again causes the MPU to energize the sound module. A tune will be played repeatedly. Improper operation (lack of or distorted sound) is easily detected during this test. If improper, refer to Sound Module Diagnostic Table, page 21.

- 5) Pressing the Self-Test button again causes the MPU to search each switch assembly for stuck contacts. If any are found, the number of the first set encountered is flashed on the Player Score displays. The number remains until the fault is cleared. Other numbers may follow if more stuck contacts are present. Note the number on the Player Score displays and refer to the Switch Matrix Diagnostic Table, Section VE, Page 16. The Switch Assembly Identification Table, stapled in the back-box, identifies each switch assembly by showing its assigned number and description. If there are no stuck switches, the number "0" appears in the Match/Ball in Play display. Pressing the Self-Test button twelve more times or turning the power OFF and ON causes the MPU to repeat the power-up test. See II, first paragraph. The game is now ready to play.

*See Figure I.

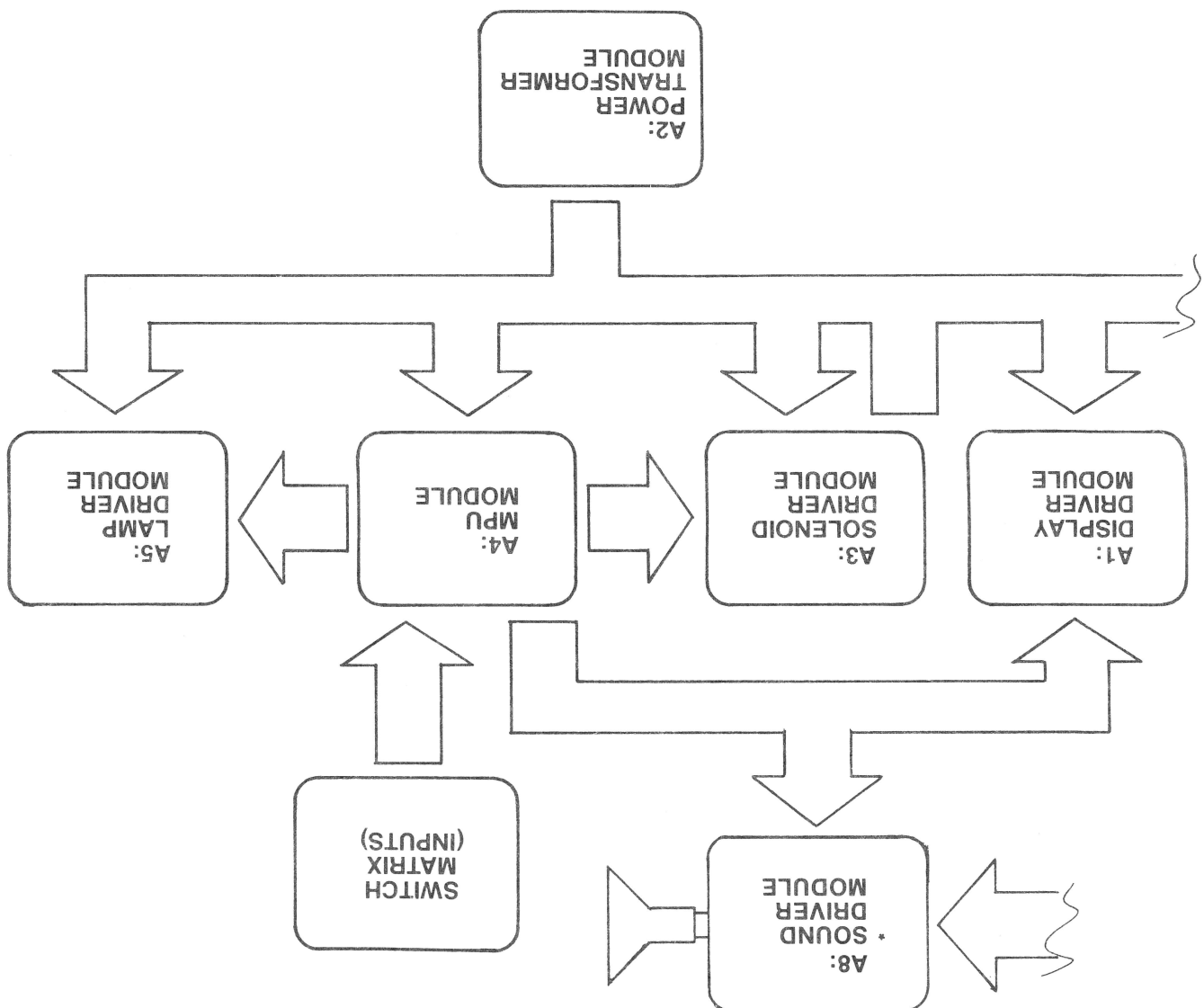
**Games (Lost World, #1119-E and Later) using Sound Modules AS-2518-32, only.
Eleven times, Freedom, Game #1066-E, only.

FIGURE 1 ELECTRONIC PINBALL MACHINE



*Lost World and Later

*Lost World and Later.



It is recommended that problems be solved in the order in which they appear in the Self Diagnostic Test routine. The reason for this is that the same fault may create misleading symptoms in subsequent test routines.

After successful completion of the Self Diagnostic Test procedure, set the game up for play. Exercise each rollover, thumper-bumper, slingshot, etc., by hand until each switch assembly on the playfield has been checked for proper operation. If actuating a switch assembly results in intermittent or no response, use AID1 and probe (See Section III and VE, Table V) to determine if the switch leaf springs have continuity to the MPU module. If incorrect, work probe back to MPU module until reason for lack of continuity is determined. If the problem is localized to the switch contacts, correct by gently closing them on a clean business card or paper and wiping until they wipe clean. Regap if necessary to $\frac{1}{16}$ ".

III. DESCRIPTION OF AID1 PROGRAM

At any time during steps 1, 2, 3 or 4 (or 5, Lost World or Later) of the Self-Diagnostic Test, a troubleshooting AID1 program can be initiated. Turn off the power. Plug in the AID1 module (J5, A4, MPU). Turn on the power. Press the self test button (See Figure I) inside the door. The AID1 program is entered by pressing S33 on the MPU module. When a game is functioning properly, entering into the AID1 program results in all displays, solenoids and switched lamps being turned off. A humming noise will be present.

AID1 permits signal continuity and adjacent lead short test to be conducted between modules. A test probe in the AID kit is clipped to TP1 on the AID1 module and is placed on the point under test. If signal continuity exists between the point and the MPU module, the LED on the MPU module lights and the humming disappears. If the LED does not light, a fault exists in the circuit. The game schematics and Figures II, III and IV permit isolation of the fault to a module or to the wiring.

When using AID1, a noise pulse introduced on the line under test can occasionally cause the MPU to 'jump the track'. If this happens, the humming noise disappears. Turn off the game. Re-enter AID1 program through the Self-Test routine.

IMPORTANT: The only exit from AID1 to the Self Diagnostic Test or normal operation is by turning the game "OFF" and then "ON" by means of the "ON-OFF" switch. The Self-Diagnostic Test can then be reinitiated by means of the button inside the door. A particular test is reinitiated by pressing the Self-Test button the appropriate number of times. See Figure III.

MODULE UNDER TEST

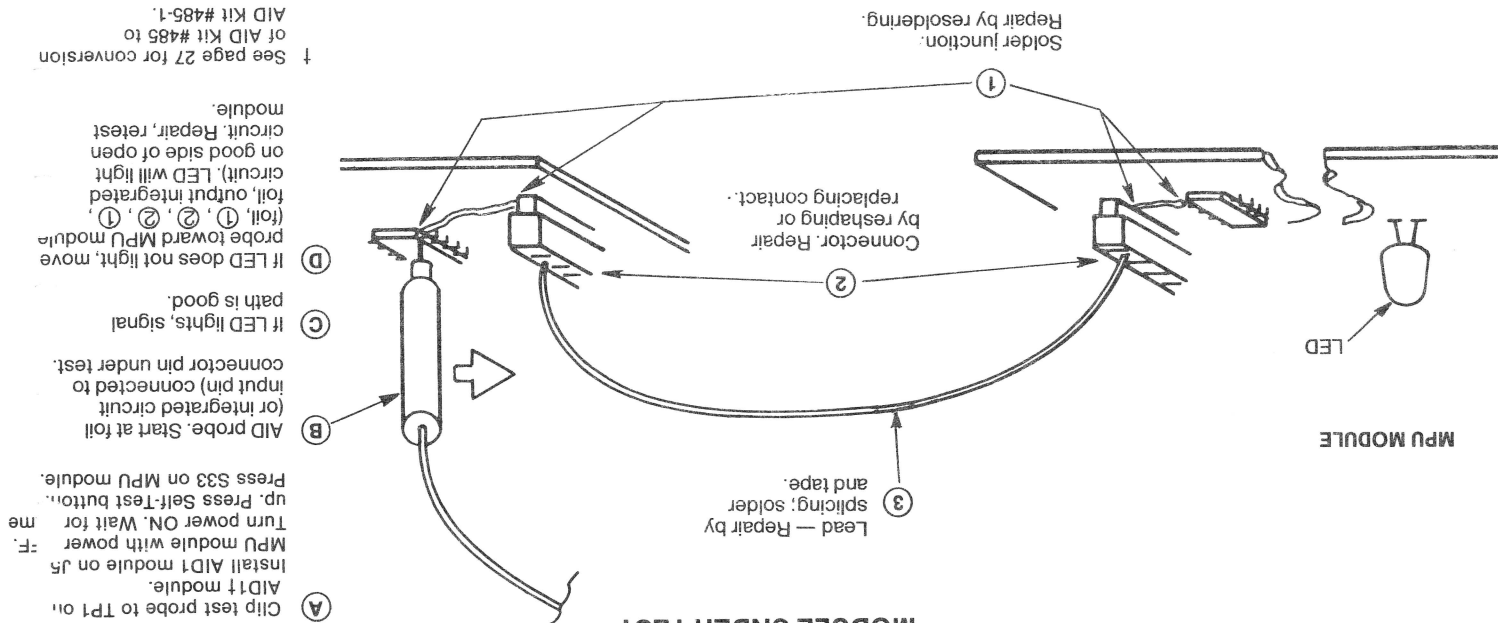
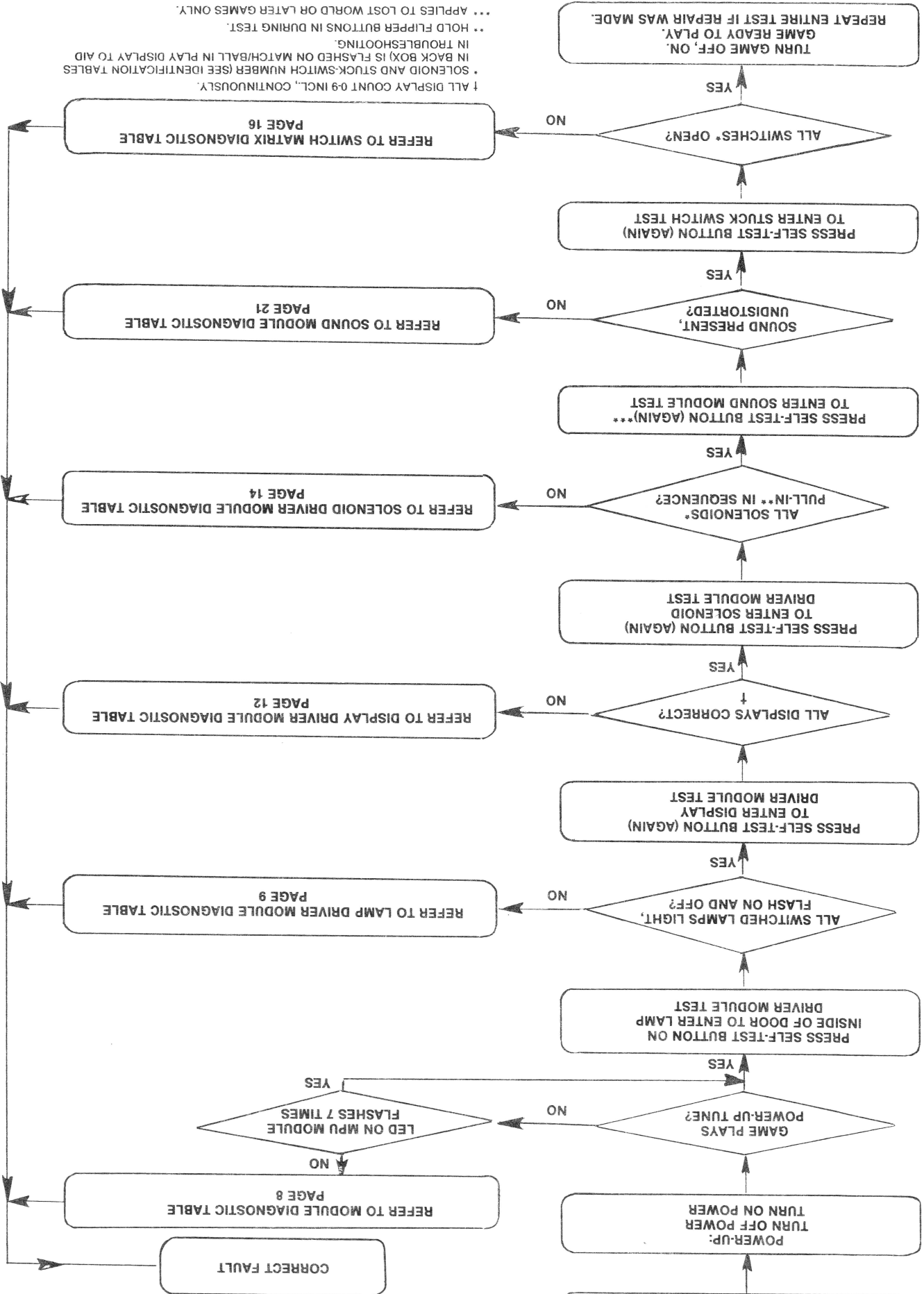


FIGURE IV USE OF THE AID1 PROGRAM IN FAULT LOCALIZATION

FIGURE III SELF DIAGNOSTIC TEST

7



IV. GENERAL

All Diagnostic procedures require that the game be opened to gain access to the parts under test. All electronic modules and some of the switched lamps are in the back box. Access to most solenoids, switches and most of the switched lamps is by raising the playfield.

ALWAYS GOOD PRACTICE

When opening the game for servicing:
Ground yourself by touching braid prior to touching modules.

Visually Inspect

- A) For broken leads.
- B) For over-heated components.

Turn-off power

- A) Before connecting* meter leads to measure line voltage.
- B) Before replacing fuses.
- C) Before removing connectors.

Exercise Due Caution When Measuring Dangerous Voltages.

Use grounded element soldering iron when making repairs in game.
Tag defective modules with fault symptoms to facilitate module repair and prevent re-entry into service inventory before repair.

* It must be assumed that the serviceman is familiar with the operation of a volt/ohmmeter. Connecting an ohmmeter to the game with the power on can damage the game, the ohmmeter or both.

V. REPAIR PROCEDURE

- 1) Follow the Self-Test procedure shown in Figure III and described in Section II.
- 2) When fault is discovered, go immediately to the appropriate Diagnostic Table. Do not go to next step in self test sequence! Read all of the symptoms in the Diagnostic Table before attempting to make a diagnosis. Follow the procedure associated with the symptom that best describes the fault.
- 3) Correct Fault.
- 4) Repeat Self-Test. When test can be run from start to end without indication of fault, check playfield switch assemblies for proper action as described in II. Corrective action, if necessary, is also given in II. After it has been determined that switch assembly action is correct, the game is ready for customer play.

VA

DIAGNOSTIC TABLE: MPU MODULE A4

REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I. LED on MPU fails to flash 7X on power-up	

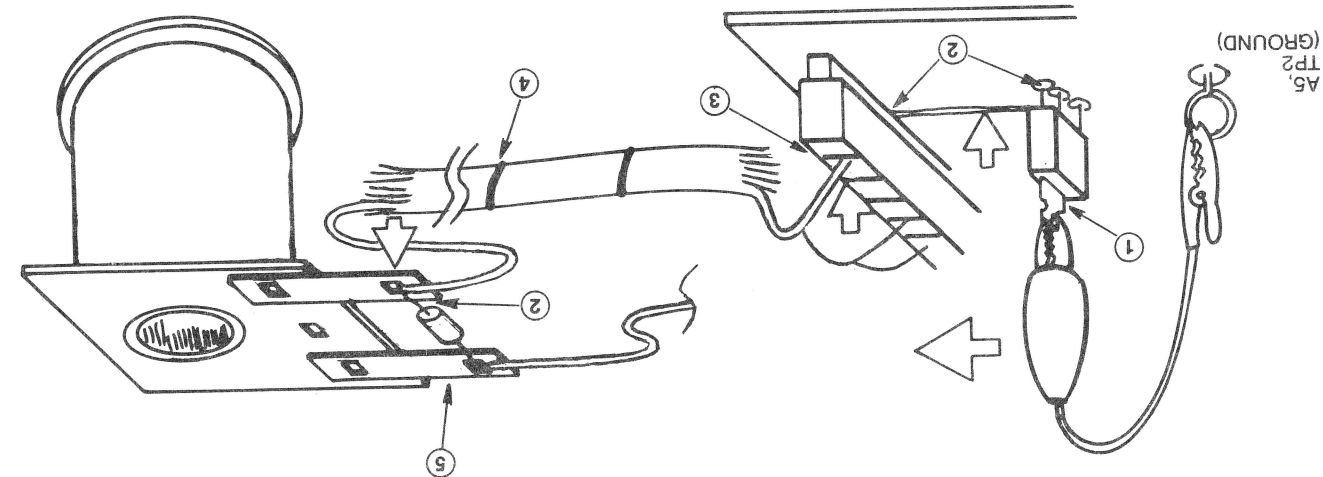
- | | | |
|-------------------------|--|--|
| A) + 5 VDC Power | MEASURE: 5 \pm .25 VDC at TP1 | If incorrect, go to Voltage Regulator Diagnostic Table. |
| B) Power Supply | MEASURE: 11.9 \pm 1.40 VDC at TP2
21.5 \pm 2.7 VDC at TP3 | If incorrect, go to Power Transformer Diagnostic Table. |
| C) Defective MPU module | | If correct, replace MPU module. Repeat Power-Up test.
If correct, repeat self-test. |

D) Shorted Lead or Shorted module input
If incorrect*, disconnect connector J1 at MPU module. Repeat Power-Up test.
If LED flashes 7X, use Self-Test to enter AID, go to Display Driver module and to Lamp Driver module Diagnostic Tables.
If LED does not flash, replace J1 and disconnect J2 and J3. Repeat Power-Up test. LED will flash 7X. Use Self-Test to enter AID. Replace J2 and J3. Go to Switch Matrix Diagnostic Table.
* MPU module replaced in (C) should be retested in known-good game. If MPU module tests good return to stock.

SYMPTOM I. One or Several (but less than 1/4 of total) lamps off.	
A) Burned out bulb	Replace bulb(s). If fault is corrected, repeat Self-Test.
B) Lack of Continuity	If incorrect use jumper from good lamp to the connected defective lamp, and light bulb or lamp socket and power source, repair, repeat Self-Test.
C) Defective module	If incorrect, replace Lamp Driver module. If correct, repeat Self-Test.
D) Broken Lead(s), etc.	If incorrect*, follow procedure in Fig. V. Repair, repeat Self-Test (Re-placed Lamp Driver module can be retested and if good returned to stock.)
*Module replaced in (C) should be retested in known-good game. If module tests good, return to stock.	

SYMPTOM II. All Lamps Off	
---------------------------	--

A) Supply Voltage	absent	Measure at lamp common: $5.4 \pm .8$ VDC. If absent, or out of limits, proceed to Transformer Module Diagnostic Table. Repair, repeat Self-Test.
B) Shorted Lamp Strobe line		If correct, remove MPU module connector J1. Use AID1, probe Lamp Strobe line on MPU module, see Table 1.
C) Defective MPU module		If LED does not light, replace MPU module. Repeat Self-Test.
D) Pinched, shorted lead(s) in cable harness		If LED does not light, fault is in cable harness. Repair, repeat Self-Test.
E) Defective Lamp Driver module		If LED lights, replace Lamp Driver Module. Repeat Self-Test.



Connect test lead to ground point on board. Ground transistor collector tab, ①, Solenoid Driver module (or SCR anode, Lamp Driver Module). Refer to schematic for game being serviced.

If solenoid pulls-in (or lamp lights), circuit is complete.
If not complete, move alligator clip as shown by arrows until solenoid pulls-in (or lamp lights).
If fault is at solder junction ②, repair by resoldering. If solenoid still does not pull-in, use ohmmeter to check for shorted diode. If defective, replace and repeat self-test.

If fault is at connector pin ③, repair by reshaping or replacing connector contact.
If fault is broken lead in cable ④, repair by splicing, soldering and taping.

If solenoid does not pull-in (or light lamp), use voltmeter at ⑤ to determine continuity to power source (solenoids, $4.3 \pm 5.4\text{VDC}$; lamps, $5.4 \pm .8\text{VDC}$).

Retest game after completing repairs.

FIGURE V — USE OF GROUNDING LEAD AND VOLTMETER IN FAULT LOCALIZATION: FOR USE WITH LAMP DRIVER MODULE AND SOLENOID DRIVER MODULE TEST PROCEDURES.

VB **DIAGNOSTIC TABLE: LAMP DRIVER MODULE** **REPAIR LEVEL: MODULE REPLACEMENT**

CAUSE		PROCEDURE	
SYMPTOM III. Half (or more) lamps always off. Few (one or more) always on.			
Shorted Address Line(s)	Use AID1, remove MPU module connector J1. Probe Lamp Address lines on MPU module. See Table I.		
		Do steps II-C, D, E as required.	
SYMPTOM IV. All lamps on, alternating with 1/4, 1/2, 3/4 on or all lamps on continuously.			
Shorted Data Line(s)	Use AID1, remove MPU module connector J1. Probe Lamp Data lines on MPU module. See Table I.		
		Do steps II-C, D, E as required.	
SYMPTOM V. A few lamps on; several flicker, others off.			

- A) Open Lamp Strobe Use AID1, probe Lamp Strobe line at Lamp Driver module foil. See Table I and Fig. IV.
- B) Defective Lamp Driver If LED lights, replace Lamp Driver module.
- module Repeat Self-Test.

DIAGNOSTIC TABLE: LAMP DRIVER MODULE
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE	PROCEDURE
-------	-----------

SYMPTOM V. A few lamps on; several flicker, others off. (Cont'd.)	C) Lack of continuity	If LED does not light, see Fig. IV to determine reason for lack of continuity. Repair and repeat Self-Test.
	D) Defective MPU module	If LED does not light at MPU foil, replace MPU module. Repeat Self-Test.
SYMPTOM VI. Half or more lamps associated with one or more integrated circuits always off.	Open Lamp Address line(s)	Use AID1, probe Lamp Address lines at Lamp Driver module foil. See Table I, Fig. IV, Do V-B, C, D as required.

SYMPTOM VII. One Fourth or more lamps always off.	Open Lamp Data line(s)	Use AID1, probe Lamp Data lines at Lamp Driver module foil. See Table I, Fig. IV, Do V-B, C, D as required.
--	-------------------------------	---

SYMPTOM VIII. Erratic Operation

Supply Voltage absent (+ 5 VDC)
 Do II-A, for 5 volt supply leg only.

SYMPTOM IX. One or several lamps always on.

A) Defective Lamp Driver module	Disconnect J1, J2 or J3 as appropriate. If Lamp goes out, replace Lamp Driver module. Repeat Self-Test.
B) Pinched, shorted lead(s) in cable harness	If lamp does not go out, fault is in cable harness. Repair, repeat Self-Test.

TABLE I — USE OF AID

A4-MPU,
 CONNECTOR J1
 PROBE AT A5, LAMP DRIVER
 MODULE, CONNECTOR J4

SIGNAL	PIN	PIN
AD ₀ Lamp Address Line	15	14
AD ₁ Lamp Address Line	14	15
AD ₂ Lamp Address Line	13	16
AD ₃ Lamp Address Line	12	17
PD ₀ Lamp Data Line	16	7
PD ₁ Lamp Data Line	17	6
PD ₂ Lamp Data Line	18	5
PD ₃ Lamp Data Line	19	4
Lamp Strobe #1	11	13

SERVICE HINTS:

- I. AID is used as a means to locate a continuity fault. See Figure IV.
- II. If the LED does not light when probing each of two adjacent leads, it is possible that a solder short exists across the foil. Visual inspection can detect this fault. If present, repair, return module to game and repeat Self-Test.

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE A1*

REPAIR LEVEL:

MODULE REPLACEMENT

PROCEDURE

CAUSE

SYMPTOM I. Zeros Flicker

Supply voltage absent Go to Voltage Regulator Diagnostic Table. Correct fault, repeat Self-Test.
(+5 VDC, TP1) If correct, go to VIII.

SYMPTOM II. Display(s) off, one, several or all.

A) Supply voltage absent Measure at TP2: 190 ± 5 VDC.

If absent, or out of limits, go to Voltage Regulator Diagnostic Procedure.
If correct, use AID1. Probe Display Latch strobe lines at MPU edge connector. See table II.

If LED lights, go to II-E.

If LED does not light, remove MPU module connector J1.
If LED does not light, replace MPU module. Repeat Self-Test.

If LED lights, replace J1. Remove J1 on applicable Display Driver module.
If LED does not light, fault is in cable harness. Repair, repeat Self-Test.

C) Pinched, shorted lead(s) in cable harness
D) Defective Display Driver module
E) Blanking Line status determination
F) Defective Display Driver module
G) Lack of continuity

If LED lights at edge connector test point, replace Display Driver module.
Repeat Self-Test.
If LED does not light, see Fig. IV to determine reason for lack of continuity.
Repair and repeat Self-Test.
If LED does not light at MPU edge connector, replace MPU module.
Repeat Self-Test.

SYMPTOM III. Display(s) read '000000', do not cycle 0-9 and off, etc., one, several or all displays.

Short on Display Latch Strobe line(s) Remove MPU module connector J1. Use AID1. Probe Display Latch Strobe lines at MPU edge connector. See Table II. Do steps II-B, C, D as required.

SYMPTOM IV. Incorrect count, all displays. MPU plays power-up tune only after J1 is removed.
Short on BCD Data Line(s) Use AID1. Probe BCD Data Lines at MPU module edge connector. See Table II. Do steps II-B, C, D as required.

SYMPTOM V. Digits missing, all displays. MPU plays power-up tune only after J1 is removed.
Short on Digit Select Line(s) Use AID1. Probe Digit Select line(s) at MPU module edge connector. See Table II. Do steps II-B, C, D as required.

SYMPTOM VI. Incorrect count, one, several or all displays.

Open BCD Data Line Use AID1. Probe BCD Data Lines at Display Driver module edge connector. See Table II and Fig. IV.
Do steps II-F, G, H as required.

* CAUTION: DANGEROUS VOLTAGES ARE PRESENT.

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE A1*

REPAIR LEVEL: MODULE REPLACEMENT (Cont'd.)

CAUSE	PROCEDURE
SYMPTOM VII. Digits missing, one several or all displays.	
Open Digit Select Line(s)	Use AID1. Probe Digit Enable Lines at Display Driver module edge connector. See Table II and Figure IV.
	Do steps II-F, G, H as required.
SYMPTOM VIII. Displays flicker, one, several or all displays.	
Open Display Latch Strobe line(s)	Use AID1. Probe Display Latch Strobe lines as Display Driver module edge connector. See Table II and Figure IV.
	Do steps II-F, G, H as required.
SYMPTOM IX. Segment(s) missing.	
Defective module	Replace module.

* CAUTION: Dangerous voltages are present.

TABLE II — USE OF AID

SIGNAL	A-4-MPU CONNECTOR J1	PROBE AT A1, DISPLAY DRIVER MODULE, CONNECTOR J1
Display Segment BCD Data	D ₀ D ₁ D ₂ D ₃	19 18 17 16
Display Latch Strobe		15
Display Blanking	10	10
Display Digit Enable	D ₆ D ₅ D ₄ D ₃ D ₂ D ₁	9 8 7 6 5 4
Six Player Game	J ₁ J ₁ J ₄	15 8 8

SERVICE HINTS:

- I. AID is used as a means to locate a continuity fault. See Figure IV.
- II. If the LED does not light when probing each of two adjacent leads, it is possible that a solder short exists across the foil. Visual inspection can detect this fault. If present, repair, return module to game and repeat Self-Test.

VD DIAGNOSTIC TABLE: SOLENOID DRIVER MODULE A3 REPAIR LEVEL: MODULE REPLACEMENT

CAUSE		PROCEDURE			
SYMPTOM I. All solenoids deenergized.					
Supply voltage(s)	absent	Measure at TP3: + 5 ± .25 VDC.	If absent, or out of limits, go to Voltage Regulator Diagnostic Table.		
SYMPTOM II. Flipper solenoids do not respond to button (deenergized).					
A) Open circuit (Specific cause to be determined)	B) Lack of continuity	Ground collector of transistor Q15 at metal tab.	If relay K1 pulls in, push flipper buttons.		
C) Defective Relay K1		If K1 does not pull in, replace module. Repeat Self-Test.			
D) Defective Solenoid Driver module	E) Lack of continuity	Remove connector J4. Use AID1. Probe J4, Pin 8.	If LED lights, replace* Solenoid Driver module. Repeat Self-Test.		
F) Defective MPU module		If LED does not light at MPU foil, replace MPU module. Repeat Self-Test.			
SYMPTOM III. Continuous duty solenoid does not pull-in.					
A) Open output circuit	B) Defective Solenoid Driver module	Ground collector of solenoid Driver Transistor at metal tab (Ex: Q19).	If solenoid does not pull-in, determine reason for lack of continuity. (See Fig. V.), repair and repeat Self-Test.		
C) Input problem		If solenoid pulls-in, remove connector J4. Use AID1, Probe appropriate pin on J4, (8, 9, 10 or 11). Do steps II-D, E & F.			
SYMPTOM IV. Momentary duty solenoid(s) do not pull-in.					
A) Blown fuse on playfield (Eight Ball and Later)	B) Lack of continuity	Replace fuse, Bally Part #E-133-44 or Little Fuse #313-001 (3AG size), no substitutes.	If correct, repeat Self-Test.		
C) Defective Solenoid Driver module		If fuse blows, locate defective solenoid or associated diode. Replace. Repeat Self-Test.			
SYMPTOM V. One half or more of impulse solenoids do not pull-in.					
Use AID1, probe Solenoid Bank Select line at Solenoid Driver module foil. See Figure IV and Table III.					
* If incorrect, use AID1, probe Solenoid Bank Select line at Solenoid Driver module foil. See Figure IV and Table III.					

DIAGNOSTIC TABLE: SOLENOID DRIVER MODULE A3

REPAIR LEVEL: (Cont'd.)

PROCEDURE

SYMPTOM VI. Flipper energized continuously.

Stuck Flipper Button Repair or replace flipper button switch assembly. Repair by burnishing contacts. Replace switch assembly if contacts badly burned. Reset assembly contact gap to 1/16".

SYMPTOM VII. One (or up to four) Momentary solenoid(s) energized continuously. See Note.

Half (or more) do not pull-in during Self-Test or Continuous Duty solenoid energized continuously. (Special Case: Flippers can be used on tilt and game over.)

- | | |
|--|--|
| <p>A) Pinched, shorted lead(s) in cable harness</p> <p>B) Defective Solenoid Driver module</p> <p>C) Defective MPU module</p> <p>D) Defective sound module</p> <p>E) Pinched, shorted lead(s) in cable harness</p> | <p>Remove connector J4.</p> <p>If solenoid(s) deenergize, repair cable harness, reconnect connector J4, repeat Self-Test.</p> <p>If no fault is found in cable harness, replace Solenoid Driver module. If solenoid(s) deenergize, repeat Self-Test.</p> <p>If solenoids do not deenergize*, replace* MPU module. If solenoid(s) deenergize, repeat Self-Test.</p> <p>If solenoids do not deenergize*, replace sound module.</p> <p>If solenoids deenergize, repeat Self-Test.</p> <p>If solenoid(s) do not deenergize*, fault is in cable output harness, J1, J2, J3 or J5. See schematic for game being serviced.</p> <p>Repair, repeat Self-Test.</p> |
|--|--|

NOTE: Momentary solenoids are not designed for continuous operation. Limit troubleshooting to the following cycle: One minute on, five minutes off. If damaged by overheating, they must be replaced before returning game to operation.

* If incorrect, return module to stock.
† Lost World or Later.

TABLE III — USE OF AID

SIGNAL			
(PB ₀) Momentary	4	A4-MPU CONNECTOR	PROBE AT A3
(PB ₁) Solenoid	3	J-4 PIN	SOLENOID DRIVER MODULE
(PB ₂) Data	2		CONNECTOR J4, PIN
(PB ₃) (PB ₄)	1		
PB ₅ Coin Lock Out	5		
PB ₆ Flipper Disable	6		
PB ₇	7		
CB ₂ Solenoid Bank Select	8		
	10		
	7		
	8		
	9		
	11		
	3		
	4		
	5		
	6		

SERVICE HINTS:

- I. AID is used as a means to locate a continuity fault. See Figure IV.
- II. If the LED does not light when probing each of two adjacent leads, it is probable that a solder short exists across the foil. Visual inspection of the MPU and Solenoid Driver modules can detect this fault. If present, repair, return module to game and repeat Self-Test.

VE
DIAGNOSTIC TABLE: SWITCH MATRIX
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE **PROCEDURE**

SYMPTOM I. Number appears on Player Score Displays during Stuck-Switch test.

Stuck Switch
Refer to Switch Assembly Identification Table, stapled in back-box. Locate Switch Assembly on playfield (coin switch, Self-Test and Credit button switches are on door. Repair or replace switch assembly. All contacts are used at low current levels. They are gold plated to prevent corrosion. Burnishing can break the finish and is NOT recommended. If cleaning is necessary, close the contacts on a clean business card or stiff paper. Draw the card between the contacts several times until they wipe clean. Regap to 1/16" contact separation. Repeat Self-Test.

NOTE: If several switches are stuck, the Self-Test routine will display the lowest numbered switch assembly only. Repeating the Self-Test after clearing one assembly allows the game to display the number of the next lowest numbered, stuck-switch assembly. Repeat the above procedure. When all switch assemblies are cleared, the stuck switch test ends by flashing '0' on the Match/Ball in play display.

VF
DIAGNOSTIC TABLE: VOLTAGE REGULATOR A3*
REPAIR LEVEL: MODULE REPLACEMENT

CAUSE

PROCEDURE

SYMPTOM I. + 5 VDC absent at module under test.

A) Lack of continuity

Measure TP1: 5 ± .25 VDC.
If voltage is present and within limits, use voltmeter to determine reason for lack of continuity between modules. Repair and repeat Self-Test.
If absent, measure TP5: 11.9 ± 1.4 VDC.
If absent, go to Power Transformer Module Diagnostic Table.
If voltage at TP5 is correct, replace Voltage Regulator module.
If voltage at TP1 is now correct, repeat Self-Test.
If incorrect, remove J4, MPU, J4, Lamp Driver module, J1, Sound module and J1, Display Driver module(s).
If voltage at TP1 is incorrect, repair pinched, shorted leads in cable harness.
If it is correct, reconnect J4 MPU module.
If voltage at TP1 is incorrect, replace MPU module.
If correct, repeat for Lamp Driver module, Sound module and each of the five Display Driver modules, one at a time.
Replace module that causes voltage at TP1 to go out of limits. Repeat Self-Test.

C) Defective MPU or Lamp Driver or Display Driver module

A) Lack of continuity

Measure TP2: 190 ± 5 VDC.
If voltage is present and within limits, use voltmeter to determine reason for lack of continuity between modules. Repair and repeat Self-Test.
If voltage at TP2 is not correct or absent, measure TP4: 230 ± 27.4 VDC. Table.
If voltage at TP4 is incorrect, go to Power Transformer Module Diagnostic Table.
If voltage at TP4 is correct, and voltage at TP2 was incorrect, but not absent, go to Step E.

***NOTE:** Voltage Regulator is part of Solenoid Driver/Voltage Regulator module.
CAUTION: Dangerous voltages are present.

CAUSE

PROCEDURE

SYMPTOM II. + 190 VDC absent at Display Driver module under test.* (Cont'd.)

B) Defective fuse

if voltage at TP4 is absent, replace fuse F2 on Power Transformer module. If voltage at TP2 is absent, replace fuse F1 on Voltage Regulator module A3 (1/4-A, Fast Bio), Bally Part #E-133-30 (not applicable to module AS-2518-16). If fuse does not blow, repeat Self-Test. If fuse blows, turn off power. Remove connector J3. Use an ohmmeter to measure J3, pin 8 on cable end of connection to ground. If J3, pin 8 is shorted, disconnect Display Driver module connectors A6 J1, one at a time.

(c) Defective Display Driver module

Driver module

F2, Power Transformer module and replace if necessary. Reconnect all connectors to Display Driver modules. Recheck connector J3, pin 8. If J3, pin 8 is shorted, continue disconnecting Display Driver module connectors, J1 until faulty module is located. When short is removed, repeat Self-Test.

D) Cable short

If short is not removed by disconnecting connector J1 from all Display Driver modules, short is in cabling. Trace lead to locate and remove short. Reconnect all connectors to Display Driver modules. Recheck connector J3, pin 8. If J3, pin 8 is shorted, repeat (C), from previous page. If short is corrected, replace Voltage Regulator module, check fuse F2, Power Transformer module and replace if necessary. Reconnect all connectors, repeat Self-Test.

F) Defective module

***NOTE:** Voltage Regulator is part of Solenoid Driver/Voltage Regulator module.
CAUTION: Dangerous voltages are present.

TABLE V — VOLTAGE DISTRIBUTION

Module	Pin	Signal	Module	Pin	Signal
VOLTAGE REGULATOR	J3-13/J3-25	+5VDC	MPU	J4-16, 17	—
A3	J3-14, 15	—	A4	—	—
J3-16	—	—	J4-12	—	—
J3-17	—	—	J4-15	—	—
J3-11	+11.9VDC	—	J3-8	+190VDC*	—
J3-12	—	—	J3-6	+230VDC	—
J3-5†	—	—	J3-10	GND	—
J3-18, 19	—	—	J3-3††	—	—
J3-20	—	—	J4-18, 19	—	—
J3-21, 22	—	—	—	—	—
LAMP DRIVER	J4-3**	—	J1-1, 2, 11, 12	—	—
A5	—	—	—	—	—
J1-20	—	—	J1-13	—	—
J1-1	—	—	J3-5	—	—
J3-9, 12	—	—	J3-17	—	—
J3-8	—	—	J3-18	—	—
—	—	—	—	—	—
—	—	—	J3-15, 16	—	—
—	—	—	J3-3, 4, 14	—	—
POWER TRANSFORMER	—	—	—	—	—
MODULE A2	—	—	—	—	—
DISPLAY DRIVER	—	—	—	—	—
A1	—	—	—	—	—

** VIA A8, J1-5
 † VIA A8, J1-9
 †† VIA A8, J1-6

} Lost World and Later.

CAUSE **PROCEDURE**

SYMPTOM I. Voltage absent or incorrect at remote module (ex: MPU J4-15, + 43 VDC)

- A) Continuity fault
 Measure at TP1: 5.4 ± .8 VDC.
 TP2: 230. ± 27.4 VDC.
 TP3: 11.9 ± 1.4 VDC.
 TP4: 7.3 ± .9 VAC.
 TP5: 43. ± 5.4 VDC.
 If correct, use VOM to determine reason for lack of continuity between modules and correct fault. See Fig. VI and Table VI. Repeat Self-Test.
 If incorrect (zero) at one test point, go to Symptom III.
 If incorrect (zero) at all test points, go to Symptom II.
 If incorrect, (out of limits, but not zero), measure line voltage at transformer across input leads. A variation of ± 10% is acceptable. (ex: A 115VDC nominal line can measure 103.5 to 126.5 VAC.)
 B) Incorrect line voltage
 If incorrect, steps must be taken to correct supply line voltage at location.
 C) Defective module
 If line is correct, replace module. Repeat Self-Test.

SYMPTOM II. Voltages absent at all remote modules.

- A) Blown fuse
 If line voltage is absent at transformer, (across input leads), replace fuse F6, 3 amps, slow blow. Repeat Self-Test.
 If fuse holds, log failure for future reference and return game to use. If F6 blows again, disconnect J1, J2, J3. Replace F6. Turn on power. If F6 blows, replace Power Transformer module, repeat Self-Test.
 B) Cable short
 If F6 does not blow, disconnect all remote module power connectors. See Table V, Page 17. Replace connectors J1, J2, J3, Power Transformer module, one at a time.
 If F6 blows, short exists in cabling. Repair, repeat Self-Test.
 C) Defective module
 Replace remote module power connectors one module at a time. Replace remote module that causes F6 to blow. Replace F6. Repeat Self-Test.

SYMPTOM III. Voltage absent — at TP5, or TP2, or TP4, or TP1, or TP3.

- Blown fuse F4 (5A)
 Blown fuse F2 (3/4A)
 Blown fuse F5 (20A)
 Blown fuse F1 (10A)
 Blown fuse F3 (4A)
 Defective module
 Replace fuse:
 Disconnect connector J1, J2*, J3 (TP5)
 Disconnect connector J3 (TP2)
 Disconnect connector J1, J2*, J3 (TP4)
 Disconnect connector J1, J3 (TP1)
 Disconnect connector J3 (TP3)
 If fuse blows, replace Power Transformer module, repeat Self-Test.
 Exception: F4, + 43VDC circuit. Locate and replace defective solenoid. If solenoids are good, then replace Power Transformer module.
 If fuse does not blow, disconnect associated remote module connectors as applicable, see Table VIA.

- A) Cable short
 Turn on power.
 Replace Power Transformer module connectors J1, J2 and J3 one at a time.
 If fuse blows, short exists in cabling. Repair, repeat Self-Test.
 For F1 and F5 faults, locate short in general illumination or switched lamps circuitry common. Repair, repeat Self-Test.
 Replace Remote module connectors one at a time. See Table VIA. Replace Remote module that causes fuse to blow. Replace fuse, repeat Self-Test.
 B) Defective Remote module

*Unplug line cord. Jumper J2-6 to connector pin 6, J2-7 to pin 7. Plug in line cord.

DIAGNOSTIC TABLE: POWER TRANSFORMER MODULE A2
REPAIR LEVEL: MODULE REPLACEMENT

TABLE VI — POWER DISTRIBUTION CIRCUITRY*

FROM A2, CONNECTOR, PIN #	TO MODULE, CONNECTOR, PIN #	FUNCTION
J2-6	A.C. LINE, HIGH	
J2-7	A.C. LINE, LOW	
J2-10	A.C. LINE, CONDUIT (SYSTEMS GROUND)	
J3-5	A3J3-6	+ 230 VDC TO VOLTAGE REGULATOR
J3-18	A3J3-3	+ 230VDC RETURN (GROUND)
J3-16	A1J1-13	+ 190VDC RETURN (GROUND)
J3-8	A3J3-11, 12	+ 11.9VDC TO VOLTAGE REGULATOR
J3-2	A3J3-10	+ 11.9VDC RETURN (GROUND)
J3-15	A3J3-21, 22	+ 5VDC RETURN (GROUND)
J1-5, 8	PLAYFIELD	7.3VAC GENERAL ILLUMINATION
J1-1, 2	PLAYFIELD	GENERAL ILLUMINATION RETURN
J2-1	CABINET	7.3VAC GENERAL ILLUMINATION
J2-5	CABINET	7.3VAC GENERAL ILLUMINATION
J3-10, 11	BACKBOX	GENERAL ILLUMINATION RETURN
J3-1, 2	BACKBOX	7.3VAC GENERAL ILLUMINATION
J1-7	PLAYFIELD	5.4VDC FEATURE LAMP BUS
J1-1, 2	PLAYFIELD	GROUND
J3-6	BACKBOX	5.4VDC FEATURE LAMP BUS
J3-3, 4, 14	BACKBOX	SWITCHED ILLUMINATION RETURN
J1-6	PLAYFIELD	+ 43VDC SOLENOID BUS
J1-2	PLAYFIELD	GROUND
J2-2	CABINET	+ 43VDC SOLENOID BUS
J2-9	CABINET	SOLENOID RETURN
J3-9	A3J3-5†	+ 43VDC TO FLIPPER RELAY A3K1
J3-12	A4J4-15	+ 43VDC ZERO CROSSING INPUT TO MPU
J3-13	BACKBOX	+ 43VDC SOLENOID BUS
J3-19	BACKBOX	SOLENOID RETURN

* Refer to Figure VI and Schematics
† VIA A8, J1-9, Sound module, Lost World and Later.

TABLE VIA — FUSE, TEST POINT, CONNECTOR LIST

POWER TRANSFORMER MODULE		REMOTE MODULE(S)	
FUSE	TEST POINT	TEST POINT	CONNECTORS
F1 (10A)	TP1	COMMON	FEATURE LAMPS
F2 (3/4A)	TP2	A3 TP4	A3 J3-6
F3 (4A)	TP3	A3 TP5	A3 J3-11, 12
F4 (5A)	TP5	A4 TP3	A4 J4-15
F5 (20A)	TP4	COMMON	GENERAL ILLUMINATION

DIAGNOSTIC TABLE: SOUND MODULE A8 (LOST WORLD AND LATER)
REPAIR LEVEL:
MODULE REPLACEMENT

CAUSE

SYMPTOM I: No Sound.

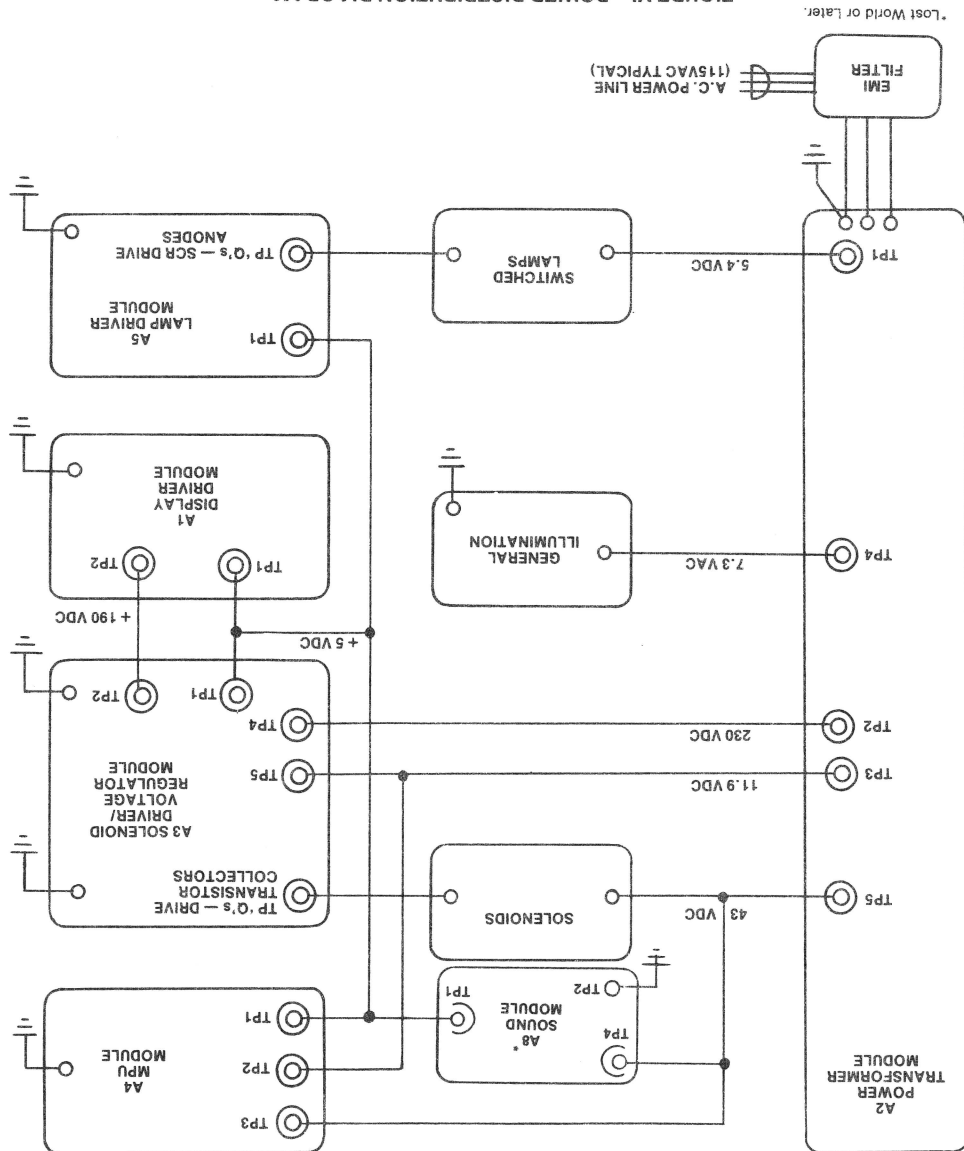
- A) Volume Control on Minimum
- B) Speaker Plug Disconnected
- C) Supply Voltage Absent
- D) Defective Sound Module
- E) Lack of Continuity

Place game in Sound Module Self-Test (Press Self-Test Switch on front door 4X). Adjust volume control on Sound Module for proper sound level. Connect plug. Do step A), above.

Measure at TP1, +5 ± .25VDC.
 If absent, or out of limits, proceed to Voltage Regulator Diagnostic Table. Repair and repeat Self-Test.
 Measure at TP4, +43VDC ± 10%.
 If absent, proceed to Transformer Module Diagnostic Table, repair, repeat Self-Test.

Measure at TP3, +12 ± 1.2VDC.
 If absent, or out of limits, replace Module.
 Use AID1. Probe input at Sound Module foil, adjacent to connector J1, pins 1, 2, 3, 4, 8 and 12. If LED lights, replace Sound Module.
 If LED does not light, use Schematics and see Figure IV to determine reason for lack of continuity or short on line. Repair, repeat Self-Test.

FIGURE VI POWER DISTRIBUTION DIAGRAM



PART II COMPONENT REPLACEMENT INDEX

I.	INTRODUCTION TO REPAIR PROCEDURE	22
II.	DESCRIPTION OF MPU TEST, SELF-DIAGNOSTIC TEST, AID	22
III.	SERVICE HINTS, GENERAL	23
IV.	DIAGNOSTIC TABLES — REPAIR PROCEDURES	23
A)	MPU MODULE, A4	24
B)	LAMP DRIVER MODULE, A5	41
C)	DISPLAY DRIVER MODULE, A1	46
D)	SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3	51
E)	POWER TRANSFORMER MODULE, A2	60
F)	SOUND MODULE, A8	65
G)	COMPUTER SOUND MODULE, A8	74

LIST OF FIGURES

FIGURE I	ELECTRONIC PIN BALL MACHINE	4
FIGURE II	ELECTRONIC GAME BLOCK DIAGRAM	5
FIGURE III	SELF DIAGNOSTIC TEST	7
FIGURE IV	SEMICONDUCTOR LEAD CONNECTIONS	80

PARTS LIST

MPU MODULE	38, 40
LAMP DRIVER MODULE	43, 44
AUXILIARY LAMP DRIVER MODULE	45
DISPLAY DRIVER MODULE	49, 50
SOLENOID DRIVER MODULE	57, 59
POWER TRANSFORMER MODULE	61, 62, 63, 64
SOUND DRIVER MODULE, AS-2518-32	72
COMPUTER SOUND MODULE, AS-2518-51	78
MODULE REPAIR SPARE PARTS KITS	80

AID, BALLY KIT #485-1, IS REQUIRED FOR USE WITH THIS PROCEDURE.
SEE PAGE 27 FOR CONVERSION OF AID KIT #485 TO AID KIT #485-1

I. INTRODUCTION

The procedures contained herein are written for use by the Service Center that cannot justify the purchase of the fully automated module test equipment available from Bally. The procedures allow fault localization, analysis and repair in an organized, direct manner. It is necessary to read, understand, and follow the procedure step-by-step until a cause for the problem is determined and the remedy for the problem, as given in the procedure, is put into effect. The few minutes spent to read and understand the procedure will prevent problems and save time.

Repair of each of the five (six, Lost World and Later) types of electronic modules used in the games is accomplished by using a known good game as a test-bed. (See Figures 1 & II, pages 4 and 5). The procedures, when used with a set of module schematics, facilitate fault localization to the defective component. Repair is accomplished by standard electronic module repair practices. A stock of replacement components is necessary. The specific memory (ROM/PRAM) chips used for each different game must also be stocked. An AID kit is required by the procedures. The modules AID mate with J5 on the MPU module. The kit is available from the Bally Service Department. Order AID, Bally Kit #485-1. No other special tools or equipment are required.

II.

The repair procedures take advantage of the two test routines designed into the game. These are the MPU Self-Test and the Self-Diagnostic Test.

- A) The MPU Self-Test occurs on power-up. The MPU module examines itself for proper operation. The MPU goes thru a sequence where it does a check-sum on its read-only memory bank, examines its read-write memory bank, exercises each peripheral input/output port, examines its inputs for the presence of line voltage zero crossings, and for the presence of display interrupts. If all is proper, the MPU module flashes the LED seven times* and announces play-readiness with the game-up tune. If, at any point in the test, performance standards are not met, the test is stopped. The game will not play until repairs are made. Counting the number of flashes that occur on power-up is used for fault localization on the MPU module.
- In a known "good game", this test is a measure of the MPU modules' ability to perform. In a defective game, the test results can be misleading if certain output lines are shorted to ground. It is necessary for purposes of the test procedures herein that the game used as a test-bed is known to be good.

- B) The Self-Diagnostic Test is a routine that causes a known-good MPU module to 'exercise' each of the other electronic modules. The symptoms that arise when a defective module is tested are listed in each of the module diagnostic tables as a means to fault localization to the defective component. Different portions of the test are associated with each of the four types of modules. A flow chart for the complete test is given in Figure III, page 7. The chart illustrates the SEQUENCE of the Self-Diagnostic Test. Instructions for entering into the appropriate portion of the test are given in the figure. The page numbers shown in the blocks are not applicable for use with this part (II) of this manual. See Figure 1, page 4 for location of Self-Test button on door.
- C) The AID Kit, Bally Kit #485-1 extends the usefulness of the Self-Diagnostic Test to locate defective components. The AID modules are plugged into J5 on the MPU module before turning the power on.

AID1 is entered from the Self-Diagnostic Test by pressing S33 on the MPU module. AID1 permits on-module signal continuity and functional checks under digital operating conditions. The test probe is clipped to TP1 and is placed in the circuit under test as detailed in the module diagnostic tables. The LED on the MPU module lights if operation in the circuit is proper. The tables detail the corrective action to be taken if the LED does not light.

When a properly operating game is in the AID1 mode, all switched incandescent display lamps and the digital display panels on the Display Driver Module are off. A humming noise may be heard. It is normal for the sound to stop as the probe is placed in various circuits in the game.

* The LED flash sequence is flicker/flash, pause, flash 6X and turn "OFF".

IMPORTANT: The only exit from AID1 to the normal operating game routines is by way of the ON-OFF switch. Simply, position the toggle to "OFF" and then again to "ON". Normal games routines or the Self-Diagnostic Test routine are then available.

AID2A is used during trouble shooting of the MPU module. It is plugged into J5 before power is turned ON. It is used to detect bus line faults on the address, data and Read/Write lines as discussed in the MPU module diagnostic tables.

III. SERVICE HINTS, GENERAL:

- A) VISUAL INSPECTION prior to servicing can often minimize service time requirements. Inspect modules for overheated components, swollen capacitors and physically damaged parts.
- B) Schematics and parts lists are essential to module servicing. Component reference designations made in the diagnostic procedures are the same as those used on the schematics and in the parts lists. Solenoid and switch assembly reference numbers are given in the tables stapled in the backbox.
- C) No special tools are required for servicing. A 20,000 Ohm/Volt meter, Simpson Model 260 or equivalent, jumper-leads, and hand tools (including a grounded element soldering iron) are considered standard servicing tools.

- D) Read all of the *Module Symptoms* in the Module Diagnostic Table before attempting to make a diagnosis. Study the symptoms presented by the defective module. Follow the procedure associated with the most applicable symptom description in the Module Diagnostic Table.
- E) Make a record of all bookkeeping functions before using AID1. When using AID1, a noise pulse induced on the line under test can occasionally cause the MPU to 'jump the track'. If this happens, turn off the game, and reenter AID1 through the Self-Test routine.
- F) The MOS and CMOS devices used in the modules are susceptible to damage from static discharge. Ground yourself, your workbench and the module under repair. Touching the ground braid in the game or the conduit in the work area frequently is a good practice. Use a grounded element soldering iron to make repairs.

- G) Clip out defective transistors and integrated circuits not in sockets to facilitate removal and prevent damage to the printed circuit boards.
- H) Use care not to flex printed circuit boards. Damage to foil or plated through holes can result from careless handling.

NOTE: It is assumed that the technician knows how to use an ohmmeter and that he knows that the power must be turned off before attempting to do so. It is further assumed that the technician can exercise proper caution when using a voltmeter to measure the line voltage and the high voltage in the Display Driver and Solenoid Driver/Voltage Regulator modules.

The procedures given herein are not all-inclusive. Faults such as intermittent operation due to poor solder joints must be left to the technicians ingenuity to discover.

MPU MODULE A4

INDEX
PROCEDURAL STEPS

A4	GENERAL & SERVICE HINTS	25
A4-I	POWER-UP PROCEDURE	28
A4-II	ROM/PROM PROCEDURE	29
A4-III	RAM PROCEDURE, NMOS	32
A4-IV	RAM PROCEDURE, CMOS	33
A4-V	PIA U10 PROCEDURE	34
A4-VI	PIA U11 PROCEDURE	34
A4-VII	DISPLAY INTERRUPT PROCEDURE	35
A4-VIII	ZERO CROSSING CIRCUIT PROCEDURE	35
A4-IX	PIA 'B' PORT PROCEDURE	36
A4-I	MPU MODULE TEST FLOW CHART	26
A4-2	CONVERSION OF AID KIT #485 TO AID KIT #485-1	27
TABLES		
A4-1	BUS ASSOCIATED FAILURES	31
PARTS LIST		
38	AS-2518-17 MPU MODULE (LESS PROM/ROM)	
40	AS-2518-35 MPU MODULE (LESS PROM/ROM)	
PAGE		

GENERAL

An MPU Self-Test occurs on power-up. Positioning the ON-OFF switch on the game to the "ON" position initiates the test. Successful completion of the test is indicated by seven flashes* of the LED (Light Emitting Diode) on the module. Figure A4-1 directs the serviceman to the proper entrance point in the diagnostic table for less than seven flashes. It is necessary to read, understand, and follow the procedure step-by-step until a cause for the problem is determined and the remedy for the problem, as given in the procedure, is put into effect. The few minutes spent to read and understand the procedure will prevent problems and save time later.

During certain steps in the procedure, it is necessary to determine the condition of the address, data & read/write lines (bus). Each line is examined for the following faults: inputs 'stuck' high or low (shorted to ground), shorts to adjacent leads and continuity between devices on the bus. The procedure also examines the status (good or failed) of several decoding integrated circuit inverters, buffers and gates on the A₉-A₁₂ address lines. To accomplish this testing with the use of a voltmeter, bus lead connection points are provided by means of J5. Continuity between devices on the bus is ascertained by the use of Table A4-1 (or the schematic) and a voltmeter.

An AID2A module, used to locate bus line faults on MPU address, data and read/write lines is included in the AID Kit, part #485-1, available from Bally, or may be made by the user. (Fig. A4-2) The AID2A module is connected before the game is turned on. It is used to ground the HALT line. When the game is turned on, the address, data and read/write bus lines all go to a high impedance state and the VMA line goes low. In this state, the clip lead on the resistor COMMON can be used to make all bus lines high (clip to +5 V) or low (clip to GND). When high, continuity to the pins of any device on the bus can be read with a voltmeter. Lines 'stuck' low due to a failed device become 'visible' to the voltmeter. When the clip is connected to ground, lines 'stuck' high due to a failed device also become 'visible'.

The GND is used to find adjacent lead shorts. The resistor COMMON lead is connected to +5 V. The GND lead is connected to each resistor, one position at a time. With the lead on a given resistor, a short to an adjacent line will result in a reading of Zero on the adjacent line. All other lines will read approximately +5 VDC.

Visual inspection can usually locate solder-splash adjacent line shorts. Removal of socketed integrated circuits one at a time locates failed devices on the line.

The MPU Self-Test is supplemented by the PIA 'B' Port procedure given in A4-IX. This procedure MUST be performed each time an MPU Module is tested. See Figure A4-1. Successful completion of the MPU Self-Test does not guarantee that the MPU module is good. Successful completion of both the MPU Self-Test and the PIA 'B' Port procedure, however, does mean that the MPU module is good. The AID1 module is used in this procedure.

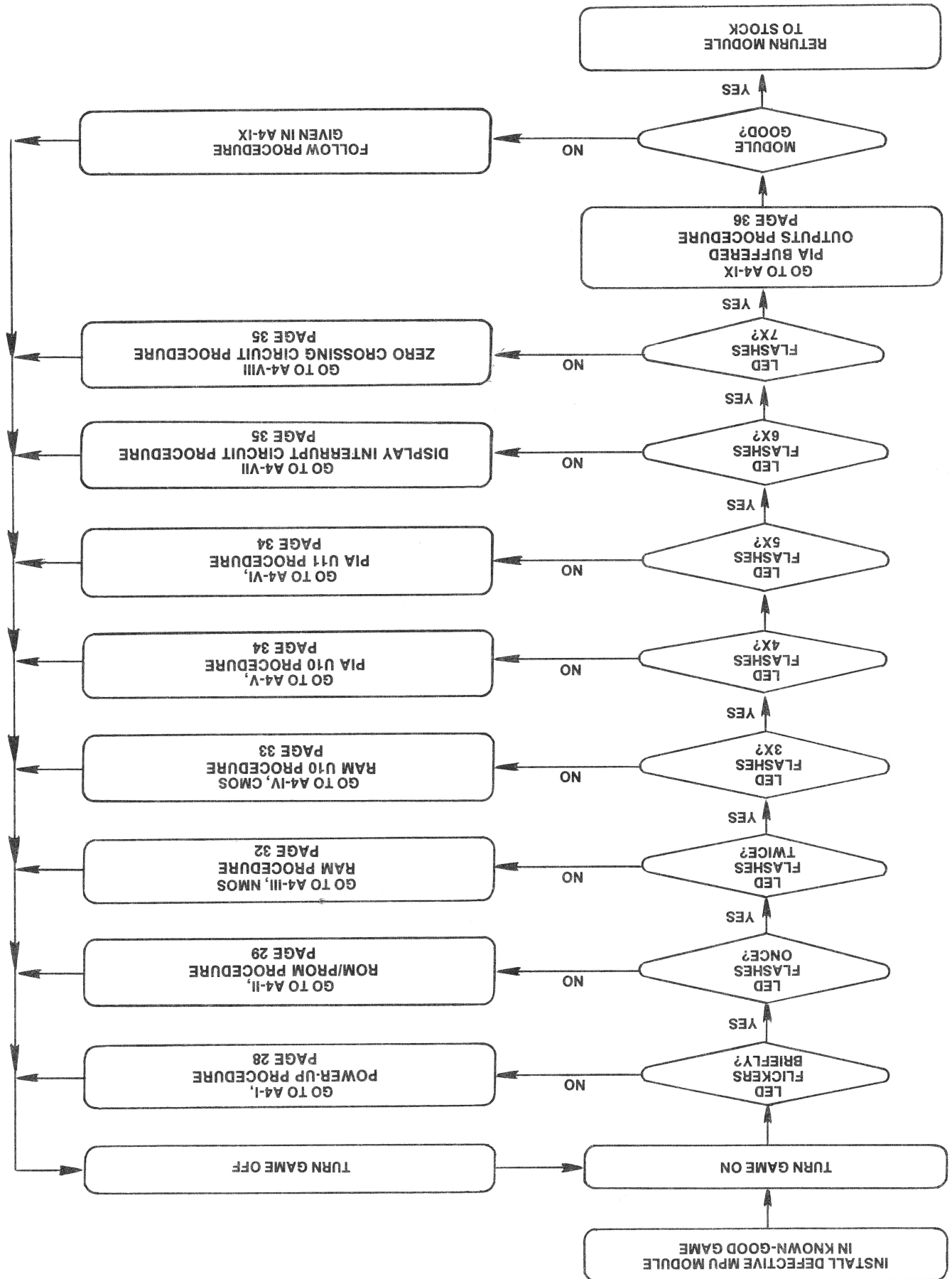
* The flash sequence is flicker/flash — pause and then 6 more flashes. The LED is turned 'off' after the seventh flash.

MPU-MODULE-TEST SERVICE HINTS

A) Voltages shown on schematic are typical operating voltages after the power-up MPU Self-Test is complete. They are dynamic in nature and represent the voltmeters response to a digital information flow at a particular point in the game program. Voltage at the output of a failed device will differ from the voltages shown. The voltages shown on the schematic are, therefore, a useful trouble shooting aid and must be used for reference.

B) The trouble shooting procedures are slanted towards ease of maintenance. If either of two devices could be the cause of malfunction, and one is soldered into the circuit and the other is inserted in a socket, the procedure will advise substitution of the socketed device first. See Caution.

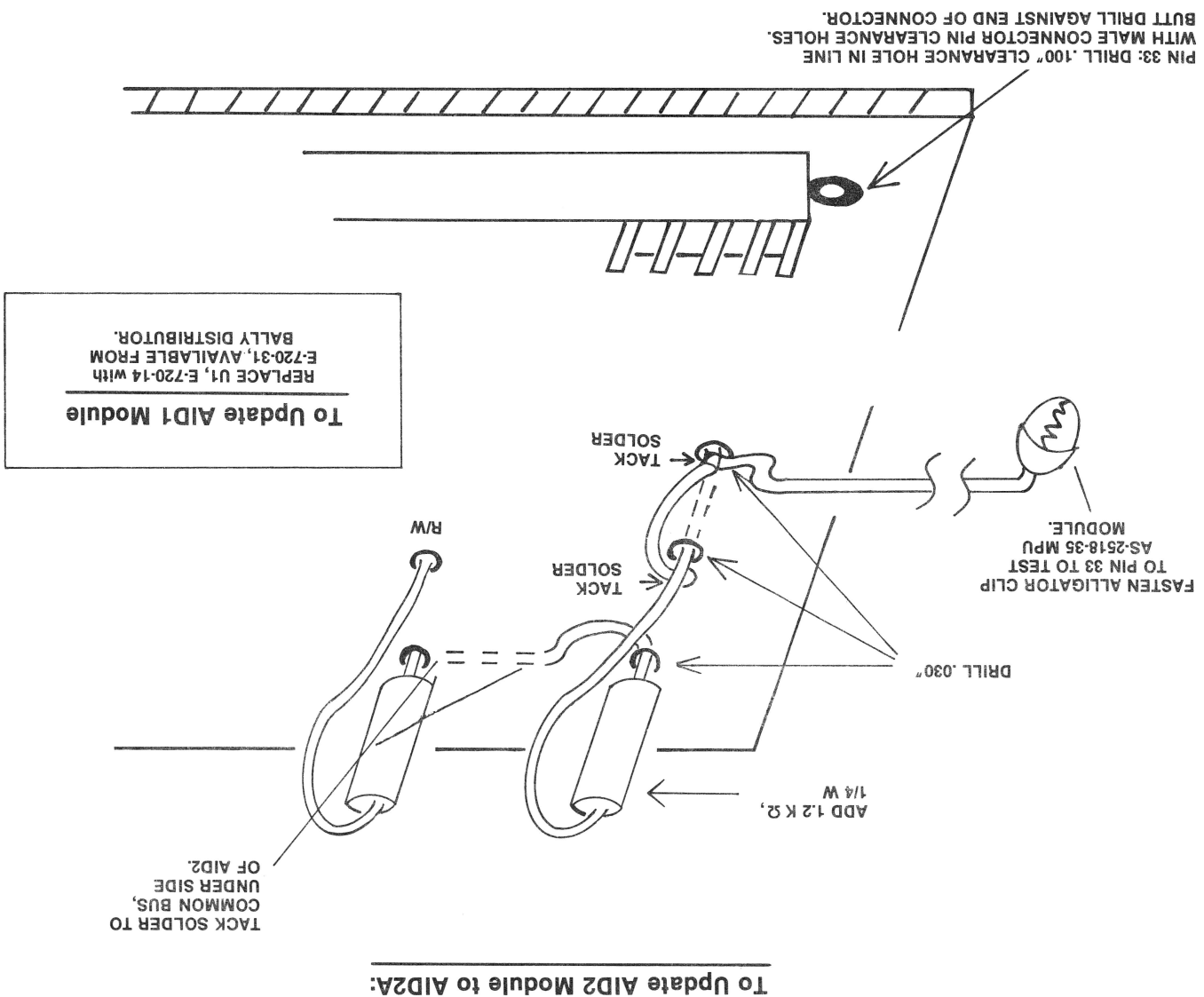
FIGURE A4-1 MPU MODULE TEST FLOW CHART



CAUTION: MOS AND CMOS integrated circuits are damaged by static charges. It is good practice to ground yourself to the braid in the game before removing or inserting an integrated circuit, to conduit-ground your work surface (bench) and tools. A grounded element soldering iron is also necessary.

- E) It is assumed that the repairman will turn off the power before using an ohmmeter, removing or inserting an integrated circuit or initiating repairs.
- D) A part number is on each ROM (or PROM), U1-U6 incl., used in the game. Each ROM (or PROM) can only be replaced with a ROM (or PROM) with an identical part number. Failure to do so will cause improper game operation.
- C) When substitution of a socket mounted device with a known-good replacement does not solve the problem, the device removed should be set aside and retested later in a known-good module. See Caution. If the device tests good, it should be returned to stock. If bad, it is recommended that several leads be cut off before discarding to mark the device as defective.

FIGURE A4-2: CONVERSION OF AID KIT #485 TO AID KIT #485-1



DIAGNOSTIC TABLE: MPU MODULE — A4-I, POWER-UP PROCEDURE

REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE PROCEDURE

SYMPTOM IA: LED always off (does not flash on Power-up).

A) Power supply line
Measure at TP2: $+11.9 \pm 1.4$ VDC. If correct, go to B).
If absent, measure $+11.9 \pm 1.4$ VDC at A3, TP5, Voltage Regulation/
Solenoid Driver module.

Open on $+11.9$ VDC
If present, locate and repair open between connector and TP2 on MPU
module. Retest module.*

Short on $+11.9$ VDC
If absent, fault should be visible, such as a solder splash caused during
repair. Locate and remove short, replace fuse F6, Power Transformer
module. Retest MPU module.*

B) Power supply line
If $+11.9$ VDC is present, measure at A4, TP1: $+5 \pm .25$ VDC. If correct,
go to C).
If absent, measure 5 volts at A3, TP1, Voltage Regulation/Solenoid
Driver module.

Open $+5$ VDC line
If present at A3, TP1, locate and repair open between connector and
TP1 on MPU module. Retest module.*

Short on $+5$ VDC line
If absent at A3, TP1, use standard trouble shooting techniques to locate
short on $+5$ volt distribution circuit on MPU module. Socketed integrated
circuits can be removed one at a time to locate fault. See CAUTION note
in Service Hints.

C) Fault in LED circuit
If voltage at TP1 is correct, remove U11 and retest module.*
If LED lights, replace U11 and retest module.
If LED does not light, check Q2 and CR8 for proper operating voltages.
Replace Q2 or CR8 as appropriate and retest module.*

SYMPTOM IB: Erratic Game operation. LED on continuously. Lamps flash or flicker, Solenoids pull-in, dropout. Displays may be energized.

Fault on BUS line
CAUTION: Turn game OFF. Continuous operation of impulse solenoids
causes permanent damage. Disconnect Solenoid Driver/Voltage Reg-
ulator module input connector A3-J4. Do procedures A4-II, Symptom IIA
page 30.

SYMPTOM IC: LED "ON" continuously

A) Fault in clock circuit
Measure at U9, pin 3: 2.4 VDC and at U9, pin 36: 2.6 VDC ($\phi 1$ and $\phi 2$,
clock circuit).
If correct, go to IC), step B).
If absent, measure the voltages as shown on the schematic at U16, pins
4, 5 and 10. If correct, go to line below 'Open Capacitor';
If incorrect, check C14 and C15 with an ohmmeter by unsoldering and
lifting one lead.

Shorted capacitor
If C14 or C15 is shorted, replace and retest module.*
If C14 & C15 are not shorted, replace U16.
If voltages at pins of U16 are now correct, retest module.*
If voltages at pins of U16 are still incorrect, replace U15.
If correct, retest module.*

U16 defective
If voltages at pins of U16 are now correct, retest module.*
U15 defective
If voltages at pins of U16 are still incorrect, replace U15.
If correct, retest module.*

Open capacitor
If incorrect after replacing U15, replace C14 and C15. Retest module.*
If voltages at U16, pins 4, 5 & 10 are correct, remove U9 from the socket.
If voltages at U9 socket, pins 3 & 36 are now correct, replace U9 &
retest module.*

U15 defective
If voltages at U9, pins 3 & 36 are not correct, replace U15. Reinsert U9
and retest module.*

* If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-I, POWER-UP PROCEDURE

REPAIR LEVEL:

COMPONENT REPLACEMENT

PROCEDURE

SYMPTOM IC: LED "ON" continuously (Cont'd.)

B) Fault on or affecting

Reset line

Measure on Reset line, U9, pin 40: 4.8VDC (Approx.).

If correct, go to IC), Step C).

If absent, use schematic and voltmeter to verify proper operation of Valid Power Detector circuit, VR1, Q1, and Q5. Collector of Q5 should read 4.8VDC.

If defective component is located in Valid Power Detector circuit, replace component and retest module.*

**in Valid Power
Detector Circuit**

If Valid Power Detector circuit voltages agree with schematic, but Reset line is low, remove U8, U9, U10 and U11, one at a time, from their sockets.

U8, U9, U10, or U11

If voltage at U9 socket, pin 40 goes to 4.8VDC, last integrated circuit removed was defective. Replace and retest module.*

Open on Reset line

If voltage at U9, pin 40 is still not correct, check for continuity between Q5, U8, U9, U10 & U11. If incorrect, determine reason for lack of continuity. Repair, retest module.* If continuity is correct, check Reset line (U9, pin 40) to ground with an ohmmeter.

Short on Reset line

If line is shorted to ground, locate and remove short. Reinsert U8, U9, U10 and U11. Retest module.*

C) Fault on HALT line

If Reset line is correct, measure at U9, pin 2: 4.95VDC (HALT).

U9 defective

If incorrect, replace U9 and retest module.*

D) Fault on VMA line

If HALT line is correct, measure at U9, pin 5: 2.8VDC (VMA line).

If incorrect, toggle on-off switch several times. Observe VMA line.

U9 defective

If initially correct and then incorrect, go to (F), below.

If incorrect, replace U9, retest module.*

E) Fault in VUA-φ2

If VMA line is correct, use voltmeter and schematic to verify proper operation of VUA-φ2 circuit, U14D, U19B, U15C and D.

circuit

If incorrect, locate and replace defective component in VUA-φ2 circuit, retest module.*

F) Fault on BUS line

Do A4-II, Symptom IIA.

DIAGNOSTIC TABLE: MPU MODULE — A4-II, ROM/PROM PROCEDURE

REPAIR LEVEL:

COMPONENT REPLACEMENT

PROCEDURE

SYMPTOM IIA: LED flickers briefly on Power-up.

A) Fault in memory bank.

U1, 2, 3, 4, 5 or 6 or

U7 or 8 defective

If LED does not flash, replace U1-6, U7, and U8, one package at a time. Repeat Power-up sequence after each substitution.

CAUTION: Each ROM or PROM must be replaced with a part with an identical part number. If LED flashes 7X, last integrated circuit replaced is defective. Retest module.*

B) Fault in PIA U10 or

U11

If LED does not flash, remove and replace U10 and U11, one package at a time. Repeat Power-up sequence after each substitution.

If LED flashes 7X, U10 or U11 is defective. Retest module.*

C) U9 failure to execute

sequence.

If LED does not flash, remove and replace U9. Repeat Power-up

If LED flashes 7X, U9 is defective. Retest module.*

* If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-II, ROM/PROM PROCEDURE

REPAIR LEVEL: COMPONENT REPLACEMENT	
CAUSE	PROCEDURE
SYMPTOM IIA: LED flickers briefly on Power-up. (Cont'd.)	D) BUS associated failure
	If LED does not flash, go to A4-II, BUS-Associated Failure Procedure.
SYMPTOM IIB: LED flickers briefly, goes off and then comes on continuously. Erratic operation: Lamps flash or flicker, solenoids pull-in, drop out.	
Fault on BUS line	
Do A4-II, BUS-Associated Failure Procedure.	

A4-II. BUS-ASSOCIATED FAILURE PROCEDURE, PROM/ROM TEST

- 1) Turn off Power. Install AID2A module on MPU connector J5.
- 2) Connect the resistor COMMON-lead to GND loop on the AID2A module. Turn on Power.
- 3) Probe resistor loops A₀ thru A₁₃, D₀ thru D₇ and R/W on AID2A with a voltmeter. All loops must read 1.2 volts or less. (At this point in the test, devices U1-11 have been replaced and are known to be good.)
If correct, go to 5.
- 4) Address lines A₉, ₁₀, ₁₁, and ₁₂, the VUA-φ₂' and the R/W line have logic gate inputs connected to them. A₉, ₁₀, ₁₁, ₁₂, VUA-φ₂' and R/W are associated with U17; A₉, ₁₁, ₁₂ and R/W with U18; A₉ and ₁₂ with U19.
If address lines A₉, ₁₀, ₁₁, ₁₂ or the R/W line do not have a solder splash, remove the associated integrated circuit(s) from the line (clip out part). Replace part(s), remove AID2A, retest module.*
- 5) Connect resistor COMMON lead to the +5 V. loop on AID2A.
- 6) Probe resistor loops A₀ thru A₁₃, D₀ thru D₇ and R/W on AID2A with a voltmeter. All loops must read 4 volts or more. If correct, go to step 8. If a line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. If present, repair, remove AID2A, retest module.* If not present, go to 7.
- 7) Repeat step 4, above.
- 8) Connect the GND lead to D₇ on AID2A. Probe D₆-D₀, A₁₄-A₀, R/W incl. on AID2A with a voltmeter. All loops must read 4 volts or more. Any lead that does not is shorted to D₇ by a solder splash. Repair, remove AID2A, retest module.*
- 9) Repeat step 8, GND lead connected to each of D₆-D₀, A₁₄-A₀, R/W, one at a time. If shorted adjacent leads are found, repair, remove AID2A and retest module.*
- 10) Disconnect the GND lead. Use Table A4-1 and a voltmeter. Check bus line continuity as follows:
 - A) Read 4 VDC or greater at U₉, pins 9-20, 22, 23 and 26-34 incl. Absence of a reading means lack of continuity. If lack of continuity exists, repair, remove AID2A, retest module.*
 - B) Repeat readings (4 volts or greater) at U₁, pins 1-11, 13-17 and 23. Temporarily connect TP1 1k 52 pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U₁, pin 18 as 1.8 VDC. Remove test lead. Read pins 19 and 20 as 4 VDC or greater.

NOTE: A₁₂ could be shorted to VUA-φ₂' if U17A were defective. If shorted, A₁₂ reads 1.8 VDC. Replace U17. Remove test connector, retest module.*

9) Repeat step 8, GND lead connected to each of D₆-D₀, A₁₄-A₀, R/W, one at a time. If shorted adjacent leads are found, repair, remove AID2A and retest module.*

10) Disconnect the GND lead. Use Table A4-1 and a voltmeter. Check bus line continuity as follows:

- A) Read 4 VDC or greater at U₉, pins 9-20, 22, 23 and 26-34 incl. Absence of a reading means lack of continuity. If lack of continuity exists, repair, remove AID2A, retest module.*
- B) Repeat readings (4 volts or greater) at U₁, pins 1-11, 13-17 and 23. Temporarily connect TP1 1k 52 pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U₁, pin 18 as 1.8 VDC. Remove test lead. Read pins 19 and 20 as 4 VDC or greater.

If any of the voltage readings are absent, repair the lack of continuity or failed logic device U17, 18 or 19, remove AID2A, retest module.*

* If LED flashes 7X, do A4-IX.

TABLE A4-1 BUS-ASSOCIATED FAILURES

BUS LINE	CPU- U9, PIN	U1	U2	ROM/PROM, PINS U3	U4	U5	U6	RAM U7, PIN
A0	9	8	8	8	8	8	8	23
A1	10	7	7	7	7	7	7	22
A2	11	6	6	6	6	6	6	21
A3	12	5	5	5	5	5	5	20
A4	13	4	4	4	4	4	4	19
A5	14	3	3	3	3	3	3	18
A6	15	2	2	2	2	2	2	17
A7	16	1	1	1	1	1	1	15
A8	17	23	23	23	23	23	23	—
A9	18	21	21	19	19	21	21	10
A10	19	19	19	21	21	19	19	11
A11	20	20	20	20	20	20	20	12
A12	22	—	—	—	—	—	—	14
D0	33	9	9	9	9	9	9	2
D1	32	10	10	10	10	10	10	3
D2	31	11	11	11	11	11	11	4
D3	30	13	13	13	13	13	13	5
D4	29	14	14	14	14	14	14	6
D5	28	15	15	15	15	15	15	7
D6	27	16	16	16	16	16	16	8
D7	26	17	17	17	17	17	17	9
R/W	34	—	—	—	—	—	—	16
A12-(VUA-φ2)	—	18	18	18	18	18	18	—
VUA-φ2?	—	—	—	—	—	—	—	13

31	18	1	2	3	4
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
21	21	21	22	35	36
25	25	22	—	35	36
—	—	—	—	—	—
—	—	—	—	—	—
23	23	—	—	—	—
26	26	6	—	—	—
27	27	5	—	—	—
28	28	21	—	—	—
29	29	—	—	—	—
30	30	1	2	3	4
31	31	2	3	4	5
32	32	3	4	5	6
33	33	4	5	6	7
24	24	5	6	7	8
—	—	6	7	8	9
—	—	7	8	9	10
—	—	8	9	10	11
—	—	9	10	11	12
—	—	10	11	12	13
—	—	11	12	13	14
—	—	12	13	14	15
—	—	13	14	15	16
—	—	14	15	16	17
—	—	15	16	17	18
—	—	16	17	18	19
—	—	17	18	19	20
—	—	18	19	20	21
—	—	19	20	21	22
—	—	20	21	22	23
—	—	21	22	23	24
—	—	22	23	24	25
—	—	23	24	25	26
—	—	24	25	26	27
—	—	25	26	27	28
—	—	26	27	28	29
—	—	27	28	29	30
—	—	28	29	30	31
—	—	29	30	31	32
—	—	30	31	32	33
—	—	31	32	33	34
—	—	32	33	34	35
—	—	33	34	35	36
—	—	34	35	36	37
—	—	35	36	37	38
—	—	36	37	38	39
—	—	37	38	39	40
—	—	38	39	40	41
—	—	39	40	41	42
—	—	40	41	42	43
—	—	41	42	43	44
—	—	42	43	44	45
—	—	43	44	45	46
—	—	44	45	46	47
—	—	45	46	47	48
—	—	46	47	48	49
—	—	47	48	49	50
—	—	48	49	50	51
—	—	49	50	51	52
—	—	50	51	52	53
—	—	51	52	53	54
—	—	52	53	54	55
—	—	53	54	55	56
—	—	54	55	56	57
—	—	55	56	57	58
—	—	56	57	58	59
—	—	57	58	59	60
—	—	58	59	60	61
—	—	59	60	61	62
—	—	60	61	62	63
—	—	61	62	63	64
—	—	62	63	64	65
—	—	63	64	65	66
—	—	64	65	66	67
—	—	65	66	67	68

A4-II. BUS-ASSOCIATED FAILURE PROCEDURE, PROM/ROM TEST (Cont'd.)

- C) Repeat (B) for U2-U6 incl. The bar over 21 (or 19 or 20, see table A4-1) requires that the resistor COMMON on AID2A be temporarily connected to the GND loop. Read 4 VDC or greater. Repair lack of continuity. Remove AID2A, and retest module.*
- D) Read 4 VDC or greater at U10, U11, pins 21-24, 26-33, 35 and 36. Absence of a reading means lack of continuity. If lack of continuity exists, repair, remove AID2A, retest module.*
- E) Temporarily connect TP1, 1k Ω pull-up (use test lead) to TP7 (R136 at end that goes to J5). Read U10, U11, pin 25 as 1.8 VDC. Repair lack of continuity. Remove AID2A, and retest module.*

DIAGNOSTIC TABLE: MPU MODULE — A4-III, RAM PROCEDURE, NMOS REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
-------	-----------

SYMPTOM III. LED flashes once on Power-Up.

- A) Fault in R/W memory Replace U7.
If LED flashes 7X on power-up, replaced integrated circuit is defective. Retest module.*
- B) U9 failure to execute If LED flashes once on Power-Up, replace U9.
If LED flashes 7X on Power-Up, retest module.*
- C) U10 or U11 defective If LED flashes once on power-up, replace U10, U11 one at a time.
If LED flashes 7X on power-up, U10 or U11 was defective; retest module.*
- D) BUS associated failure If LED flashes once on power-up, go to A4-III, BUS-Associated Failure Procedure.

A4-III. BUS-ASSOCIATED FAILURE PROCEDURE, RAM TEST

- 1) Turn off power. Install AID2A on MPU connector J5.
- 2) Connect the resistor COMMON lead to GND loop on the AID2A module. Turn on power.
- 3) Probe R/W resistor loop on AID2A with a voltmeter. The loop must read 1.2 volts or less. (At this point in the test, devices U7, 9, 10 and 11 have been replaced.) If correct, go to 5.
- 4) If the R/W line does not have a solder splash, remove the associated integrated circuit U18 from module. Repair, remove AID2A, retest module.*
- 5) Connect resistor COMMON lead to the +5 V. loop, AID2A.
- 6) Probe R/W resistor loop on AID2A with a voltmeter. The loop must read 4 volts or more. If correct, go to 8. If the line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. Repair, remove AID2A, retest module.*
- 7) Repeat step 4, above. If good, go to step 8.
- 8) Connect the GND lead to R/W on AID2A. Probe D₇-D₀, A₁₄-A₀ incl., on AID2A with a voltmeter. All loops must read 4 volts or more. Any lead that does not is shorted to R/W by a solder splash. Repair, remove AID2A, retest module.*
- 9) Disconnect the GND lead. Use Table A4-1 and a voltmeter. Check bus line continuity as follows:
 - Read 4 VDC or greater at U7, pins 2-9, 11, 12 and 14-23, incl. Absence of a reading means lack of continuity. Temporarily connect TP1, 1k Ω pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U7, pin 13 as 2.2 VDC. Absence of a reading means lack of continuity. Remove test lead. The bar over 10 (see table A4-1) requires that the resistor COMMON on AID2A be temporarily connected to the GND loop. Read 4 VDC or greater. Absence of a reading means lack of continuity.
 - If lack of continuity exists, repair, remove AID2A, retest module.*

DIAGNOSTIC TABLE: MPU MODULE — A4-IV, RAM PROCEDURE, CMOS

REPAIR LEVEL:

COMPONENT REPLACEMENT

PROCEDURE

CAUSE

SYMPTOM IV. LED flashes twice on power-up.

A) Fault in R/W memory	Replace U8. If LED flashes 7X on power-up, integrated circuit is defective.
B) U9 failure to execute	If LED flashes twice on Power-up, replace U9. Retest module.*
C) U10 or U11 defective	If LED flashes 7X on power-up, retest module.* If LED flashes twice on power-up, replace U10, U11, one at a time.
D) BUS associated failure	If LED flashes twice on power-up, go to A4-IV, BUS-Associated Failure Procedure.

A4-IV. BUS-ASSOCIATED FAILURE PROCEDURE, RAM TEST

- 1) Turn off power. Install AID2A module on MPU connector J5.
- 2) Connect the resistor COMMON lead to GND loop on the AID2A module. Turn on power.
- 3) Probe R/W resistor loop on AID2A with a voltmeter. The loop must read 1.2 volts or less. (At this point in the test, devices U8, 9 and 10 have been replaced.) If correct, go to 5. If the line reads greater than 1.2 volts, check for a solder splash to an adjacent, high lead on the module. Repair, remove AID2A, retest module.*
- 4) If the R/W line does not have a solder splash, remove the associated integrated circuitry U18 from the line (clip out part). Replace part, remove AID2A, retest module.*
- 5) Connect resistor COMMON lead to the +5 V. loop on AID2A.
- 6) Probe R/W resistor loop on AID2A with a voltmeter. The loop must read 4 volts or more. If correct, go to 8. If the line reads 0 VDC, check for solder splash to ground or to an adjacent lead held low. Repair, remove AID2A, retest module.*
- 7) Repeat step 4, above. If good, go to step 8.
- 8) Connect the GND lead to R/W on AID2A. Probe D₇-D₀, A₁₄-A₀ incl. on AID2A with a voltmeter. All loops must read 4 volts or more. Any lead that does not is shorted R/W by a solder splash. Repair, remove AID2A, retest module.*
- 9) Disconnect the GND lead. Use Table A4-1 and a voltmeter. Check bus line continuity as follows:
 - Read 4 volts or greater at U8, pins 1-7, 9-17, 20 and 21. Read pin 19 as 2.6 VDC. The bar over R/W at 18 (see table A4-1) requires that the resistor COMMON on AID2A be connected to the GND loop. Read 4 VDC or greater.
 - If any of the voltage readings are absent, repair the lack of continuity or replace the failed logic device U8 or associated logic devices U17, U18 or U19; remove AID2A, retest module.*

* If LED flashes 7X, do A4-IX.

DIAGNOSTIC TABLE: MPU MODULE — A4-V, PIA U10 PROCEDURE

REPAIR LEVEL: COMPONENT REPLACEMENT

SYMPTOM V. LED flashes 3X on Power-up.

CAUSE	PROCEDURE
A) Defective I/O circuit Replace U10.	If LED flashes 7X on Power-up, retest module.*
B) U9 failure to execute U10 defective	If LED flashes 3X on Power-up, replace U9.
C) Fault on output line U9 defective	If LED flashes 7X on Power-up, retest module.*
D) Fault on input line Defective capacitor or shorted line	If LED flashes 3X on Power-up, remove U10, use schematic and ohm-meter to check output lines at U10 socket, pins 2-9, for shorts to ground. If shorted capacitor or solder-splashed line is found, replace/repair. Retest module.*

If output lines are correct, go to A4-V, BUS-Associated Failure Procedure.

A4-V. BUS-ASSOCIATED FAILURE PROCEDURE, PIA U10 TEST

- 1) Turn off power. Install AID2A module on MPU connector J5.
 - 2) Connect the resistor COMMON lead to the +5 V. loop on the AID2A module. Turn on power.
 - 3) Use Table A4-1 and a voltmeter.
 - A) Read 4 VDC or greater at U10, pins 21-24, 26-33, 35 and 36 incl. Absence of a reading means lack of continuity. If lack of continuity exists, repair, remove AID2A, retest module.*
 - B) Temporarily connect TP1, 1k Ω pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U10, pin 25 as 1.8 VDC. Remove test lead.
- If any of the voltage readings are absent, repair the lack of continuity or failed logic device U17, remove AID2A, retest the module.*

DIAGNOSTIC TABLE: MPU MODULE — A4-VI, PIA U11 PROCEDURE

REPAIR LEVEL: COMPONENT REPLACEMENT

SYMPTOM VI. LED flashes 4X on Power-up.

CAUSE	PROCEDURE
A) Defective I/O circuit Replace U11.	If LED flashes 7X on Power-up, retest module.*
B) U9 failure to execute U11 defective	If LED flashes 4X on Power-up, replace U9.
C) Fault on output line U9 defective	If LED flashes 7X on Power-up, retest module.*
D) Fault on input line	If LED flashes 4X on Power-up, use ohmmeter and schematic to check output lines at U11 socket, pins 2-9 for shorts to ground. If shorted capacitor or solder-splashed line is found, replace/repair. Retest module.*

If output lines are correct, go to A4-VI, BUS-Associated Failure Procedure.

A4-VI. BUS-ASSOCIATED FAILURE PROCEDURE, PIA U11 TEST

1) Turn off power. Install AID2A module on MPU connector J5.

2) Connect the resistor COMMON lead to the +5 loop on the AID2A module. Turn on power.

3) Use Table A4-1 and a voltmeter.

- A) Read 4 VDC or greater at U11, pins 21-24, 26-33, 35 and 36 incl. Absence of a reading means lack of continuity. If lack of continuity exists, repair. Remove AID2A, retest module.*
- B) Temporarily connect TP1, 1k Ω pull-up (use test lead) to TP7 (R136 at the end that goes to J5). Read U11, pin 25 as 1.8 VDC. Remove test lead.
- If any of the voltage readings are absent, repair the lack of continuity or failed logic device U17, remove AID2A, retest the module.*

DIAGNOSTIC TABLE: MPU MODULE — A4-VII, DISPLAY INTERRUPT CIRCUIT PROCEDURE

REPAIR LEVEL:

COMPONENT REPLACEMENT

CAUSE PROCEDURE

SYMPTOM VII. LED flashes 5X on Power-up.

A) Fault in interrupt circuit

Use Ohmmeter to affirm continuity between U9, pin 4 and U11, pins 37 & 38. Measure from U9, pin 4 to ground to check for short.

Open or shorted line

If incorrect, repair open or short condition. Retest module.*

If correct, replace U11.

If LED flashes 7X on Power-up, retest module.*

B) U9 failure to execute

If LED flashes 5X on Power-up, replace U9.

If LED flashed 7X on Power-up, retest module.*

If LED flashed 5X on Power-up, check voltage at U12 against voltages shown on schematic.

C) Fault in interrupt generator circuit

Open line

If correct, use ohmmeter to determine reason for lack of continuity to U11, pin 40. Repair, retest module.*

If voltages at U12 are incorrect, replace U12.

If LED flashes 7X on Power-up, retest module.*

If LED flashes 5X replace C16 and C17. Retest module.*

Defective capacitor

Defective U12

DIAGNOSTIC TABLE: MPU MODULE — A4-VIII, (LAMP AND SOLENOID INTERRUPT) ZERO CROSSING CIRCUIT

REPAIR LEVEL:

COMPONENT REPLACEMENT

CAUSE PROCEDURE

SYMPTOM VIII. LED flashes 6X on Power-up.

A) Fault in interrupt circuit

Use Ohmmeter to affirm continuity between U11, pins 37 and the following: U11, pin 38; U10, pin 37; U10, pin 38; U9, pin 4. Measure to ground to check for short.

Open line

If incorrect, repair open circuit and retest module.*

If correct, replace U10.

If LED flashes 7X on Power-up, retest module.*

If LED flashes 6X on Power-up, use schematic and voltmeter to check operation of Zero Crossing Detector circuit U14.

Measure .25VDC at U14, pin 4, & U14, pin 15; 4.5VDC @ U14, pin 10 & U14, pin 14.

If correct, use ohmmeter to determine reason for lack of continuity to U10, pin 18. Repair, retest module.*

Open or shorted line

If incorrect, change U14

U18 or U19 defective

-or-

Determine reason for lack of continuity to input connector, as appropriate. Voltage at TP3, if proper, reads 21.5 \pm 2.7VDC. Repair, retest module.*

Open or shorted line

U18 or U19 defective

Open or shorted line

* If LED flashes 7X, do A4-IX.

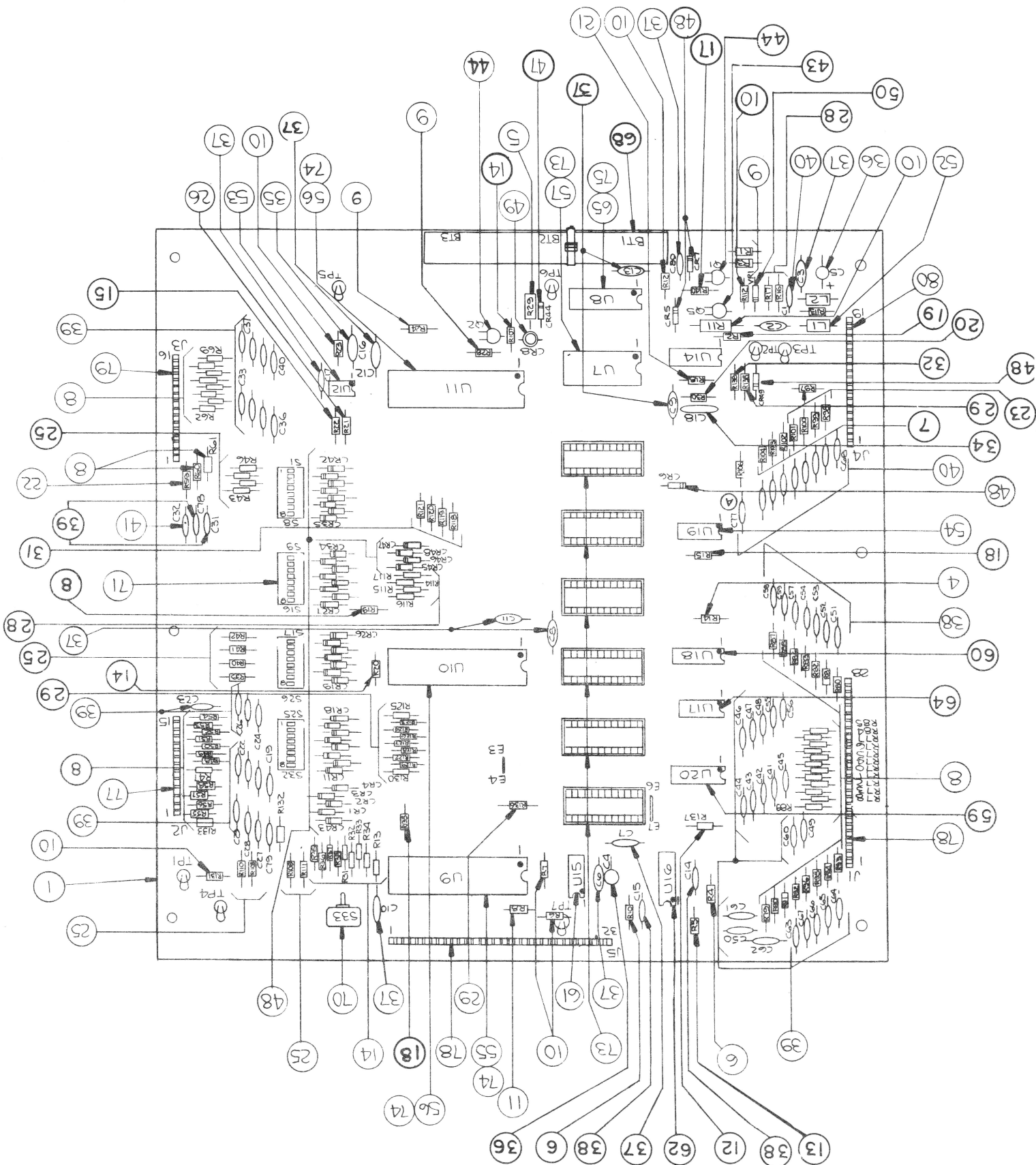
DIAGNOSTIC TABLE: MPU MODULE — A4-IX, PIA OUTPUTS PROCEDURE

REPAIR LEVEL:

COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM IX. LED flashes 7X on Power-up. Game operation improper.	
A) Fault in PIA U11	Turn game OFF. Connect AID1 to J5 on MPU. Turn power ON. Put game in Self-Test mode of operation. Use AID1 and schematic. Probe output connector and pins listed. LED lights to indicate proper operation.
B) Fault in PIA U10	Remove connector A3J4, Solenoid Driver module. Probe A4J4, pins 1-8 and 10 incl.
U11 defective	If correct, replace A3J4, go to B).
Open or shorted output line	If incorrect: If U11 was not replaced during previous testing, replace U11. Repeat test on J4.
U11 defective	If correct, proceed to B).
Open or shorted output line	If incorrect, determine reason for short or open on line.
U10 defective	Repair, retest module.
Fault in PIA U10	Probe J2, pins 8-15 and J3, pins 9-16 incl.
switch Matrix buffered output circuit	If correct, go to C).
C) Fault on buffered display blanking line (CA2)	If incorrect: If U10 was not replaced during previous testing, replace U10. Repeat test on J2, J3. If correct, proceed to C).
Open line	If incorrect, probe U19, pin 4. If correct, determine reason for lack of continuity. Repair and retest module.
U10 defective	If U19, pin 4 is incorrect, and U10 has not been previously changed, replace U10. Retest module.
U20, 14 or 19 defective	If incorrect, use voltmeter, voltages shown on schematic, to localize fault to U20, U14 or U19. Repair, retest module.
Fault on Display Latch	Probe J1, pins 20-24.
Strobe buffered lines	If correct, go to E). If incorrect: NOTE LINE.
Open line	Probe U20 outputs, pins 2, 5, 7, 9 and 11, as appropriate.
U10 and U11 defective	If correct, determine reason for lack of continuity. Repair, retest module.
U20 output defective	If incorrect, and U10 and U11 were not replaced in previous testing, remove U10 and U11. Replace and retest module.
E) Open line, PIA non-buffered outputs	If incorrect, replace U20, retest module.
	Probe J2, pins 1-5; J3, pins 2, 3; J1, pins 1-7, 12-19 and 25-28.
	If incorrect, determine reason for lack of continuity. Repair, retest module.
	If correct, return module to stock.

AS-2518-17 MPU MODULE For AS-2518-35, See Page 39



A4: MPU MODULE COMPONENT PARTS LIST

ITEM	REFERENCE	BALLY PART #	DESCRIPTION
1	A4 (see note 1)	AS-2887-XXXX	MPU Module Complete.
2	A4 (see note 2)	AS-2518-17	MPU Module less Program Memory, U1-6 incl. See page 37.
3-32	See Schematic		Resistors, See schematic for value.
34	C18	E-00586-0019	Capacitor, .05 MFD, 100V
35	C16	E-00586-0081	Capacitor, .1 MFD, 100V
36	C4, C5	E-00586-0073	Capacitor, 4.5 MFD, 25V
37	C3, C6-C13, C17	E-00586-0065	Capacitor, .01 MFD, 500V
38	C14, C15, C79, C41-C67	E-00586-0067	Capacitor, 470 PFD, 1kv
39	C19-C31, C78, C33-C40	E-00586-0069	Capacitor, 390 PFD, 1kv
40	C1, C2, C68-C77	E-00586-0070	Capacitor, 820 PFD, 1kv
41	C32	E-00586-0077	Capacitor, 3000 PF, 1kv
43	Q5	E-00585-0023	Transistor PNP (MPS-3702)
44	Q1, Q2	E-00585-0031	Transistor (2N3904)
47	CR44	E-00587-0006	Diode (1N4004)
48	CR1-CR7, CR11-CR43, CR45-CR48	E-00587-0014	Diode (1N4148)
49	CR8	E-00679	LED (Green)
50	VR1	E-00598-0008	Diode Zener (8.2V, 1W9598)
52	L1, L2	E-00604-0003	Inductor, 22 Micro Hy.
53	U12	E-00620-0004	Timer (555)
54	U19	E-00620-0005	Quad 2 Input (4011)
55	U9	E-00620-0028	MPU I.C. (6800)
56	U10, U11	E-00620-0029	PIA I.C. (6820)
57	U7	E-00620-0030	RAM I.C. (6810)
59	U20	E-00620-0032	HEX Buffer I.C. (14502B)
60	U14, U18	E-00620-0033	HEX Inverter (4049B)
61	U15	E-00620-0034	Quad Memory Driver (MC3459L)
62	U16	E-00620-0035	Dual Monostable (9602)
64	U17	E-00620-0041	Quad 2 Inputs (74L00N)
65	U8	E-00620-0042	RAM (C MOS, P5101L-3)
68	BT1, BT2, BT3	E-00628-0002	Battery
70	S33	E-00658-0001	Push Button Switch
71	S1-S8, S9-S16, S17-S24, S25-S32	E-00677	DIP Switch
73		E-00712	24 Pin Socket
74		E-00712-0001	40 Pin Socket
75		E-00712-0003	22 Pin Socket
77	J2	E-00715	15 Pin Water Connector
78	J4, J5	E-00715-0004	28 Pin Water Connector
79	J3	E-00715-0017	16 Pin Water Connector
80	J1	E-00715-0018	19 Pin Water Connector
81	J5	E-00715-0023	4 Pin Water Connector

NOTE 1:

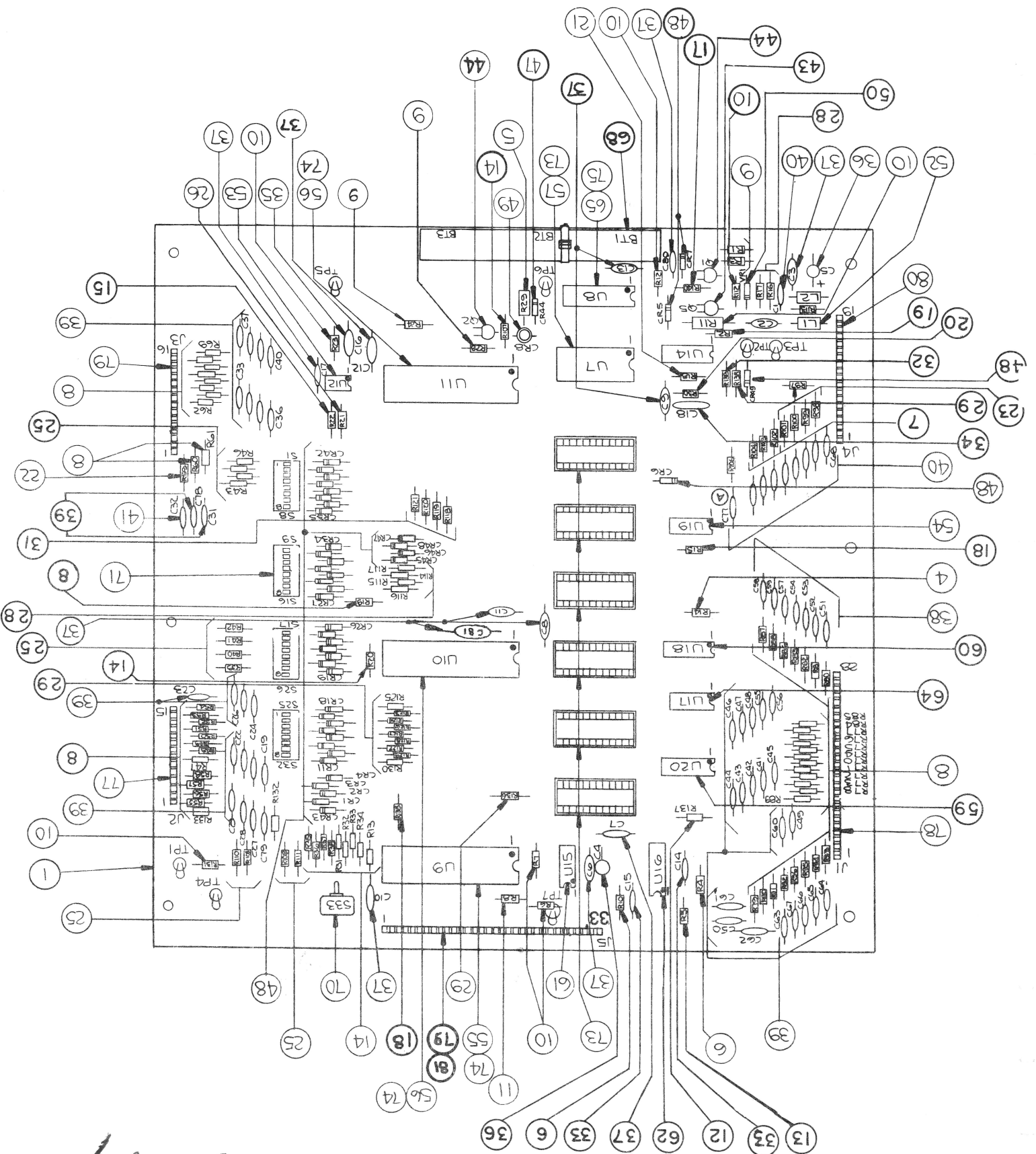
When ordering, fill in dash number. For example, AS-2887-1: FREEDOM, AS-2887-2: NIGHT RIDER, AS-2887-3: EVEL KNIEVEL

NOTE 2:

Order replacement memory chips U1-U6, by specifying game, socket and part number stamped on chip.

AS-2518-35 MPU MODULE Used in Lost World and Later

Me 6821
L90997



A4: MPU MODULE COMPONENT PARTS LIST

ITEM	REFERENCE	BALLY PART #	DESCRIPTION
1	A4 (see note 1)	AS-2962-0	MPU Module Complete.
2	A4 (see note 2)	AS-2518-35	MPU Module less Program Memory, U1-6 incl.
3-32	See Schematic		Resistors, See schematic for value.
33	C14, C15	E-00586-0067	Capacitor, 470 PFD, 1kv
34	C18	E-00586-0088	Capacitor, .05 MFD, 16V
35	C16	E-00586-0081	Capacitor, .1 MFD, 100V
36	C4, C5	E-00586-0073	Capacitor, 4.5 MFD, 25V
37	C3, C6-C13, C17, C81	E-00586-0085	Capacitor, .01 MFD, 25V
38	C79, C41-C67	E-00586-0083	Capacitor, 470 PFD, 50V
39	C19-C31, C78, C33-C40	E-00586-0082	Capacitor, 390 PFD, 50V
40	C1, C2, C68-C77	E-00586-0084	Capacitor, 820 PFD, 50V
41	C32	E-00586-0077	Capacitor, 3000 PF, 1kv
43	Q5	E-00585-0023	Transistor PNP (MPS-3702)
44	Q1, Q2	E-00585-0031	Transistor (2N3904)
47	CR44	E-00587-0006	Diode (IN4004)
48	CR1-CR7, CR11-CR43, CR45-CR48	E-00587-0014	Diode (IN4148)
49	CR8	E-00679	LED (Green)
50	VR1	E-00598-0008	Diode Zener (8.2V, IN9598)
52	L1, L2	E-00604-0003	Inductor, 22 Micro Hy.
53	U12	E-00620-0004	Timer (555)
54	U19	E-00620-0005	Quad 2 Input (4011)
55	U9	E-00620-0028	MPU I.C. (6800)
56	U10, U11	E-00620-0029	PIA I.C. (6820)
57	U7	E-00620-0030	RAM I.C. (6810)
59	U20	E-00620-0032	HEX Buffer I.C. (14502B)
60	U14, U18	E-00620-0033	HEX Inverter (4049B)
61	U15	E-00620-0034	Quad Memory Driver (MC3459L)
62	U16	E-00620-0035	Dual Monostable (9602)
64	U17	E-00620-0041	Quad 2 Inputs (74L00N)
65	U8	E-00620-0042	RAM (C MOS, P5101L-3)
68	BT1, BT2, BT3	E-00628-0003	Battery
70	S33	E-00658-0001	Push Button Switch
71	S1-S8, S9-S16, S17-S24, S25-S32	E-00677	DIP Switch
73		E-00712	24 Pin Socket
74		E-00712-0001	40 Pin Socket
75		E-00712-0003	22 Pin Socket
77	J2	E-00715	15 Pin Water Connector
78	J1	E-00715-0004	28 Pin Water Connector
79	J3, J5	E-00715-0017	16 Pin Water Connector
80	J4	E-00715-0018	19 Pin Water Connector
81	J5	E-00715-0024	17 Pin Water Connector

NOTE 1:

When ordering, fill in dash number. For example, AS-2962-0: LOST WORLD.

NOTE 2:

Order replacement memory chips U1-U6, specifying game, socket and part number stamped on chip.

LAMP DRIVER MODULE AS PROCEDURAL STEPS

- I. The Lamp Driver module part of the Self-Test energizes each of the sixty lamp driver output circuits on the module. The game used as a test bed, however, may not have a lamp assigned to each of the output circuits. If it does not, the following procedure can be followed:
 - A) Use the Lamp Driver module part of the Self-Test. If faults are found, use the symptoms to select a repair procedure. Restore the module to operating condition by following the procedure.
 - B) Use the test bed game schematic. Make a list of the Lamp Driver circuits that did not have lamp loads.
 - C) The LED on the MPU module is used as a substitute for a lamp load. If the circuit under test is good, the LED will flash on and off just as the lamps in the test bed game do. Access to the anode of the first Lamp Driver SCR on the list is available at J1, J2 or J3. Refer to the Lamp Driver module schematic. Insert a 3/4" piece of solid wire (ex: a resistor lead clipping) into the connector contact position to be tested. Connect a test lead from TP6 on the MPU module to the piece of wire.
 - D) Repeat A.
 - E) Repeat C and A for each of the remaining Lamp Driver circuits on the list.* Return the module to stock or repair, as required.
- II. Lamp Bank Extender modules can be tested in the test bed game.

If the game has provision for a Lamp Bank Extender, insert the module in its proper place and conduct the Lamp Driver module part of the Self-Test. The procedure above must be followed to test unused outputs.

If the game does not have provision for a Lamp Bank Extender module, insert it in the Lamp Driver position. Connect J4, cable harness to J4 on the module, J2 to J2. Testing is the same as for the game with provision for the module. Unused outputs can also be tested. Lamp assignments are given on the test bed game Lamp Driver module schematic.

* Connecting a lamp-loaded SCR anode to TP6 causes the LED to flicker, alternating between bright and dim.

DIAGNOSTIC TABLE: LAMP DRIVER MODULE, AS REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I. Lamp always off.	
A) Defective SCR	Use jumper to connect pull-up resistor at TP3 (R70, 2K 2) to gate of SCR (silicon controlled rectifier). (Ex: Q10)
B) Defective buffer amplifier	If lamp does not turn on, replace SCR. Retest module.
C) Defective integrated circuit	If lamp turns on and buffer amplifier (Ex: U5) is used, replace buffer. Retest module. If fault is not corrected, go to step "C".
	If lamp turns on and no buffer amplifier is used (Ex: Q1) or if changing buffer did not correct problem, replace associated integrated circuit (Ex: U1). Retest module.
SYMPTOM II. Lamp always on.	
A) Defective SCR	Use jumper to ground (TP2) SCR gate (Ex: Q10). If lamp does not go out, replace SCR, retest module.
B) Defective buffer amplifier	If lamp goes out and buffer amplifier (Ex: U5) is used, use jumper to ground buffer amplifier input.
C) Defective integrated circuit	If lamp does not go out, replace buffer amplifier, retest module.

- A) Defective SCR

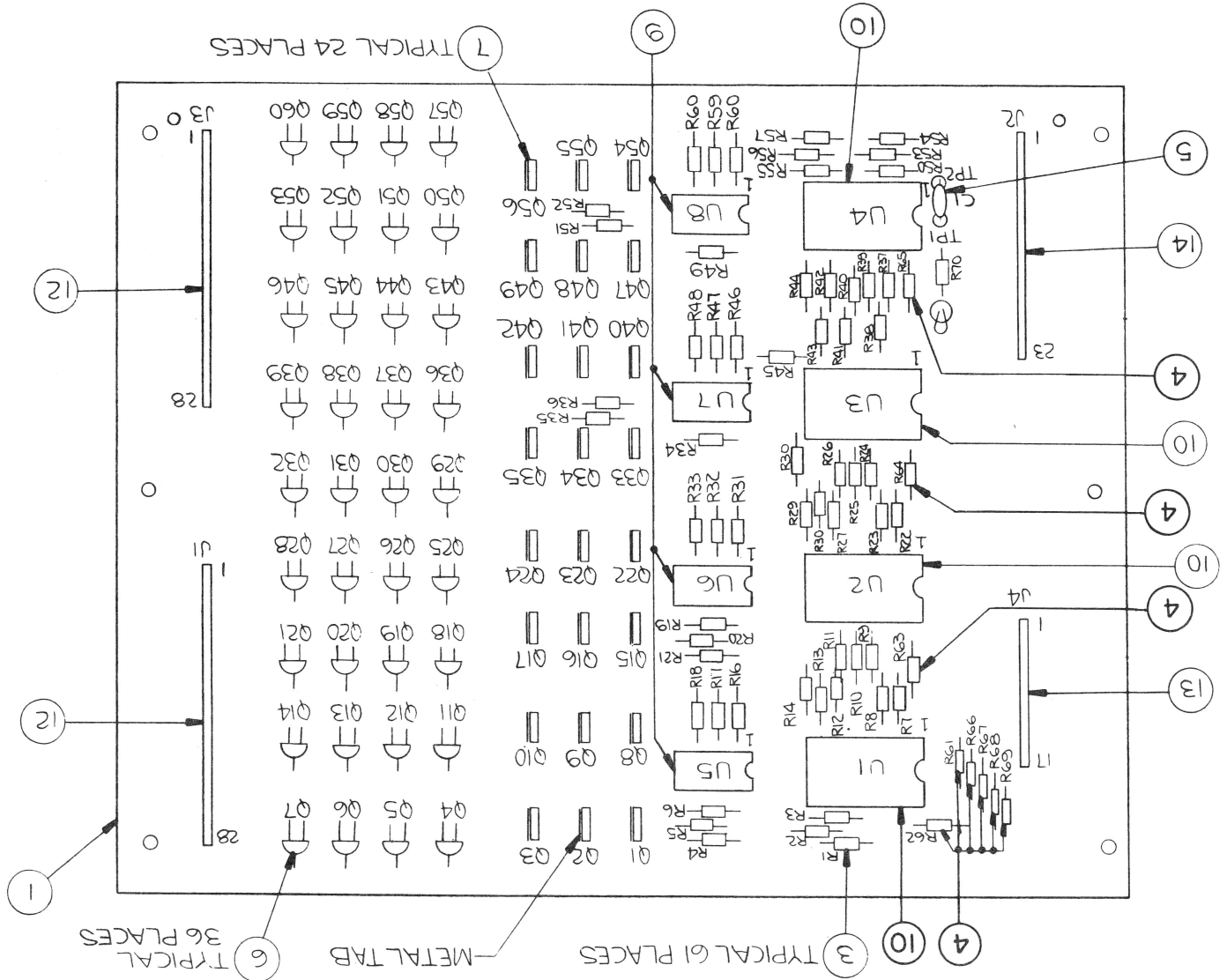
Use jumper to ground (TP2) SCR gate (Ex: Q10). If lamp does not go out, replace SCR, retest module.
- B) Defective buffer amplifier

If lamp goes out and buffer amplifier (Ex: U5) is used, use jumper to ground buffer amplifier input.
- C) Defective integrated circuit

If lamp does not go out, replace associated integrated circuit (Ex: U1). Retest module.

CAUSE		PROCEDURE	
SYMPTOM III. Half or more of lamps associated with one or all integrated circuit(s) flicker or always off.			
A) Open address line	Use AID1, probe pins 2, 3, 21 & 22 (U1, U2, U3 or U4). If LED does not light, use schematic to determine reason for lack of continuity. Repair, retest module.	B) Defective integrated circuit	If LED lights, replace appropriate integrated circuit (U1, U2, U3 or U4). Retest module.
SYMPTOM IV. One fourth (or more) of total lamps, all associated with one (or several) integrated circuit(s) always off.			
A) Open data line	Use AID1. Probe pin 23 of fault associated integrated circuit(s). If LED does not light, determine reason for lack of continuity. Repair, retest module.	B) Defective integrated circuit	If LED lights, replace appropriate integrated circuit (U1, U2, U3 or U4). Retest module.
SYMPTOM V. A few lamps on, several flicker, others off, associated with one or all integrated circuit(s).			
A) Open strobe line	Use AID1. Probe pin 1 of fault associated integrated circuit(s). If LED does not light, determine reason for lack of continuity. Repair, retest module.	B) Defective integrated circuit	If LED lights, replace appropriate integrated circuit (U1, U2, U3 or U4). Retest module.
SYMPTOM VI. Half or more lamps always off alternating with a few always on.			
A) Shorted address line due to defective integrated circuit	Use AID1. Probe pins 2, 3, 21 & 22. Hold probe on line that does not light LED. Cut foil associated with line that does not light LED close to integrated circuit, one at a time until LED lights. Replace integrated circuit, repair foil cuts with jumper wire and solder. Retest module.		
SYMPTOM VII. One fourth of lamps always on.			
A) Shorted data line due to defective integrated circuit	Replace integrated circuit associated with one fourth lamps always on. Retest module.		
SYMPTOM VIII. All lamps off except four (4). (one per integrated circuit.)			
A) Shorted lampstrobe line due to defective integrated circuit	Repeat procedure VI for U1, U2, U3, U4, pin 1.		
SYMPTOM IX. MPU does not flash LED on power-up.			
Short on + 5VDC line	Remove capacitor C1. Measure + 5VDC at TP1.	A) Defective capacitor C1	If correct, discard and replace C1. Retest module.
B) Defective integrated circuit	If incorrect, repeat foil cutting procedure, Symptom VI for U1, 2, 3, 4, pin 24.		
SYMPTOM X. All lamps off, or erratic operation, no voltage at TP1.			
+ 5VDC supply voltage absent	Use voltmeter to determine reason for lack of continuity. Repair, retest module.		

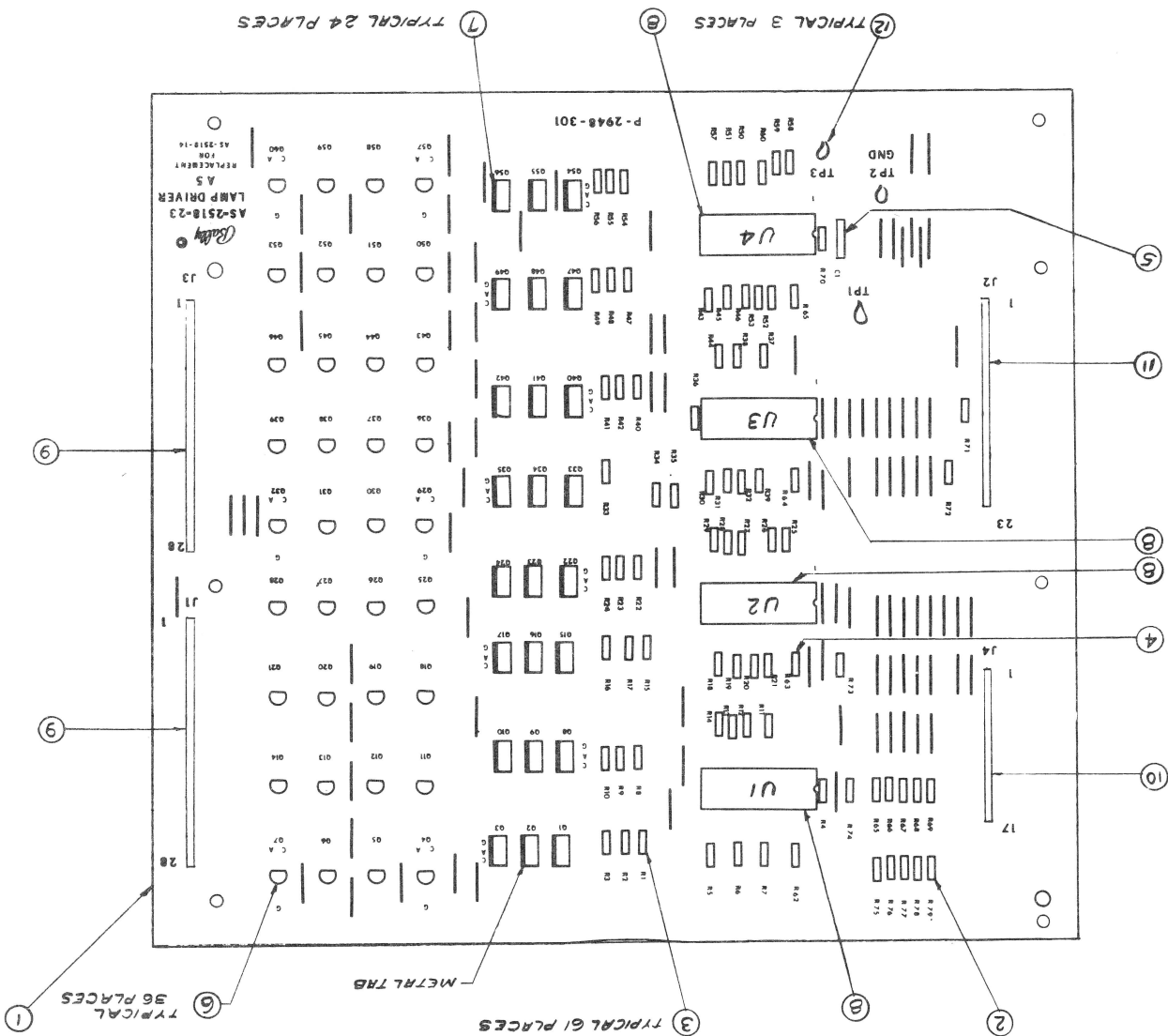
AS-2518-14 LAMP DRIVER MODULE



A5: LAMP DRIVER MODULE COMPONENT PARTS LIST

ITEM	REFERENCE	BALLY PART #	DESCRIPTION
1	A5	AS-2518-14	Lamp Driver Module, Complete
3	R1-R60, R70	E-00105-0237	Resistor, 2k Ω , 5%, 1/4W
4	R61-R69	E-00105-0256	Resistor, 2.2M Ω , 1/4W
5	C1	E-00586-0065	Capacitor, .01 MFD, 500V
6	Q4-Q7, Q11-Q14, Q18-Q21, Q25-Q32, Q36-Q39, Q43-Q46, Q50-Q53, Q57, Q58	E-00585-0014	SCR, 2N5060
7	Q1-Q3, Q8-Q10, Q15-Q17, Q22-Q24, Q33-Q35, Q40-Q42, Q47-Q49, Q54-Q56	E-00585-0029	SCR, MCR106-1
9	U5-U8	E-00620-0007	I.C., Buffer, CD4050AE
10	U1-U4	E-00620-0037	I.C., Decoder, 14514B
12	J1, J3	E-00715-0004	28 Pin Wafer Connector
13	J1	E-00715-0013	17 Pin Wafer Connector
14	J4	E-00715-0014	23 Pin Wafer Connector

AS-2518-23 LAMP DRIVER MODULE

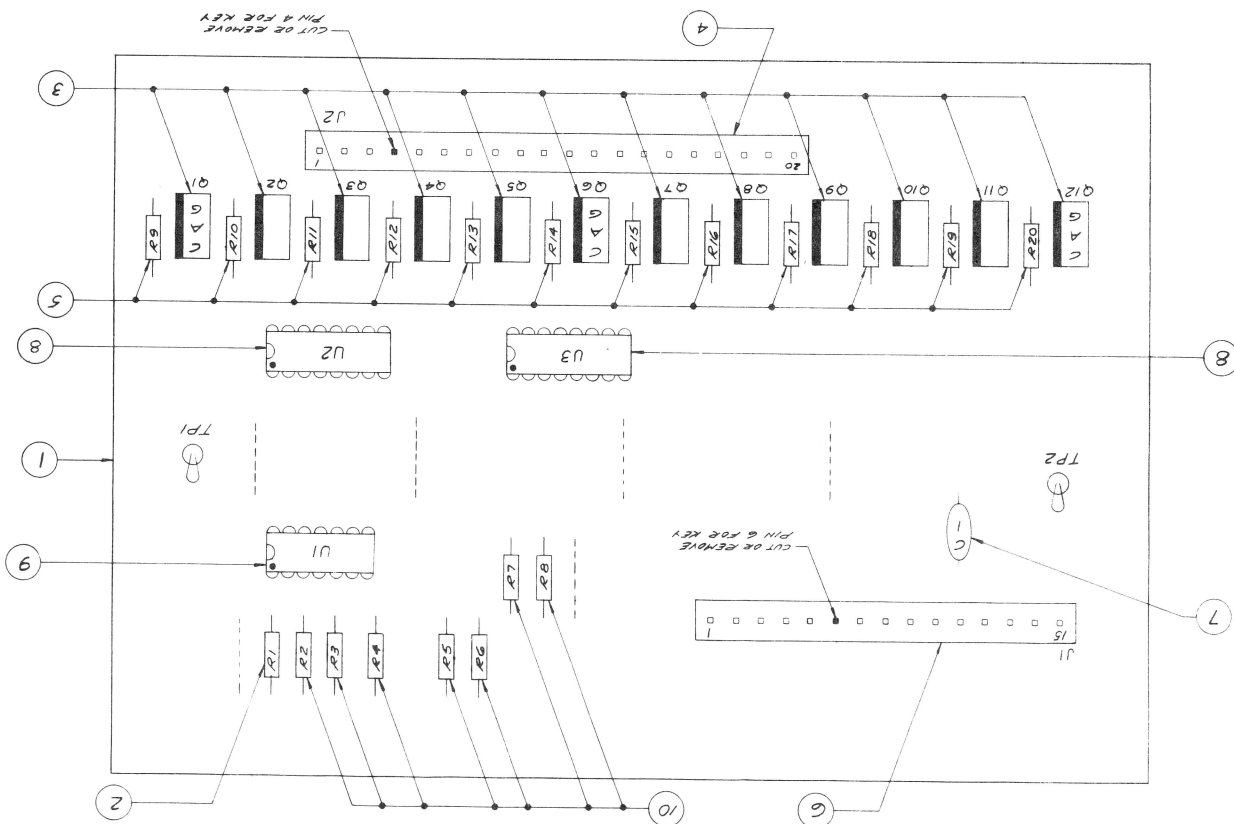


AS: LAMP DRIVER MODULE COMPONENT PARTS LIST

ITEM	REFERENCE	BALLY PART #	DESCRIPTION
1	A5	AS-2518-23	Lamp Driver Module, Complete
2	R71-R79	E-00105-242	Resistor, 20k Ω , 5%, 1/4 W
3	R1-R60, R70	E-00105-0237	Resistor, 2k Ω , 5%, 1/4 W
4	R61-R69	E-00105-0256	Resistor, 2.2M Ω , 1/4 W
5	C1	E-00586-0065	Capacitor, .01 MFD, 500V
6	Q4-Q7, Q11-Q14, Q18-Q21, Q25-Q32, Q36-Q39, Q43-Q46, Q50-Q53, Q57-Q60	E-00585-0014	SCR, 2N5060
7	Q1-Q3, Q8-Q10, Q15-Q17, Q22-Q24, Q33-Q35, Q40-Q42, Q47-Q49, Q54-Q56	E-00585-0029	SCR, MCR106-1
8	U1-U4	E-00620-0037	I.C., Decoder, 14514B
9	J1, J3	E-00715-0004	28 Pin Wafer Connector
10	J4	E-00715-0013	17 Pin Wafer Connector
11	J2	E-00715-0014	23 Pin Wafer Connector
12	TP1, TP2, TP3	P-05399	Test Clip

NOTE: INTERCHANGEABLE WITH AS-2518-14.

AS-2518-43 AUXILIARY LAMP DRIVER



A9: AUXILIARY LAMP DRIVER COMPONENT PARTS LIST

ITEM	QTY.	REFERENCE DESIGNATION	PART NO.	DESCRIPTION
1	1	R1	P-2948-355	P.C. Board (M-645-461)
2	1	Q1 Thru Q12	E-105-173	Resistor 2.2 Meg. Ω
3	12	J1	E-585-29	SCR MCR 106-1
4	2	J2	E-715-34	10 Pin Water Pin Connector
5	12	R9 Thru R20	E-105-237	Resistor 2K Ω
6	1	J1	E-715-39	15 Pin Water Pin Connector
7	1	C1	E-00586-0065	Capacitor .01 MFD
8	2	U3, U2	E-620-84	MC14555B Binary 1 to 4
9	1	U1	E-620-85	MC14013B Dual D Flip Flop
10	7	R2 Thru R8	E-105-242	Resistor 20K Ω

DISPLAY DRIVER MODULE A1 PROCEDURAL STEPS

CAUTION

- I. Before inserting module in game, probe the 190 VDC circuit to ground, TP2 to TP3, with an ohm-meter. Clear shorts, if present, *before* inserting module in game. Shorts on the 190 VDC supply line can cause failure of the Solenoid Driver/Voltage Regulator module, A3.
- II. High voltages are present in the display panel driver circuits (+ 190 VDC) on this module. Exercise due caution when servicing.
- III. Careless or accidental probe slips that short the + 190 VDC circuit to ground or to the + 5 VDC or logic circuits can cause failure of the Solenoid Driver/Voltage Regulator module (A3) and MPU module (A4). It is recommended that a standard or needle tipped probe similar to the AID probe be used to perform voltage checks. Alligator clip leads are to be avoided unless special precautions are taken.

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE, A1 REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE	PROCEDURE
SYMPTOM I. Mottled, Uneven or dim display.	
Display at end of useful life	Replace Display Panel.
SYMPTOM II. Digit Fails to light.	

- A) Lack of continuity
 - Use AID which pro junction of page resistor (old style display AS-2518-15-R2, 4, 6, 8, 10, or 12, if appropriate; new style display AS-2518-21-R43, 44, 45, 46, 47 or 48, if appropriate) and connector.
 - If LED does not light, determine reason for lack of continuity. Repair, retest module.
 - If LED lights, turn game off, then on, enter Display Driver Self-Test. Ground collector (Ex: junction of Q6, R11) of level shifter transistor.*
 - If digit does not light, replace digit driver transistor (Ex: Q12). Retest module.
- B) Defective Digit Driver Transistor
 - If digit lights, replace level shifter transistor. Retest module.
- C) Defective level shifter transistor
 - If digit lights, replace level shifter transistor. Retest module.

SYMPTOM III. Digit brighter than adjacent digits (Digit always on).

- A) Defective level shifter transistor (Ex: Q6)
 - Use AID1 to effectively ground base of level shifter. Carefully connect jumper lead from TP2 (+ 190VDC) to base of digit driver transistor. If digit turns off, replace level shifter transistor. Retest module.
- B) Defective digit driver transistor
 - If digit does not turn off, replace digit driver transistor. Retest module.

* To prevent damage to Display Panel due to overheating, Limit Time Jumper is in circuit to 60 seconds or less. TP3 is a convenient ground point.

PROCEDURE

CAUSE

SYMPTOM IV. Segment always ON. (See Table "A")

A) Defective segment driver transistor	Use AID1. Probe base, segment driver transistor (Ex: Q13). If LED lights, replace transistor, retest module.
B) Defective segment driver transistor & Integrated Circuit U1	If LED does not light, measure voltage at base of segment driver transistor. If greater than +5 VDC (Ex: +110 VDC) replace transistor and U1 segment decoder. Retest module.
C) Defective Integrated circuit U1	If +5 VDC, replace U1. Retest module.

SYMPTOM V. Segment Always OFF. (See Table "B")

A) Defective segment driver transistor	Use AID1. Probe base, segment driver transistor (Ex: Q13). If LED lights, replace transistor. Retest Module.
B) Defective Integrated Circuit U1	If LED does not light, unsolder and remove base lead of transistor from foil on board. Probe foil.
	If LED lights, replace segment driver transistor. Retest module.
	If LED does not light, replace U1, segment decoder. Retest module.

SYMPTOM VI. Display Count is improper.

A) Ex: 1,1,3,3,5,5,7,7,9,9,- or 2,3,2,3,6,7,6,7,-,- or 4,5,6,7,4,5,6,7,-,- or 8,9,-,-,-,-,-,8,9,- or etc.	A) Lack of continuity	Use AID1. Probe address inputs at U1, pins 2, 3, 4 & 5.
		If LED does not light, determine reason for lack of continuity to connector. Repair, retest module.
		If LED lights, replace U1. Retest module.
B) Defective Integrated Circuit U1	A) Short on Address	Use AID1. Probe address inputs at U1, pins 2, 3, 4, & 5. If short exists between foil traces, repair, retest module.
B) Defective Integrated Circuit U1		If short does not exist between traces, replace U1. Retest module.

SYMPTOM VII. No Display or digits flicker.

A) Open on +5 VDC Supply Line	Measure 5 ± .25 VDC at TP1 and at U1, pin 16. If absent, determine reason for lack of continuity. Repair, retest module.
B) Open on +190 VDC Supply Line	If +5 present, measure 190 ± 5 VDC at TP2. If absent, check connector for 190 VDC. If present, determine reason for lack of continuity. Repair, retest module.
C) Short on +190 VDC Supply Line	Repair, retest module.
D) Defective Integrated Circuit U1	If 190 VDC is present in step "B", replace integrated circuit U1. Retest module.

$$\frac{f \frac{g}{b}}{e \frac{d}{c}}$$

TABLE "A" — SEGMENT ALWAYS ON

COUNT	a	b	c	d	e	f	g
0	0	0	0	0	0	0	0
1	7	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

TABLE "B" — SEGMENT ALWAYS OFF

0	0	1	2	3	4	5	6	7	8	9
1	1	2	3	4	5	6	7	8	9	0
2	2	3	4	5	6	7	8	9	0	1
3	3	4	5	6	7	8	9	0	1	2
4	4	5	6	7	8	9	0	1	2	3
5	5	6	7	8	9	0	1	2	3	4
6	6	7	8	9	0	1	2	3	4	5
7	7	8	9	0	1	2	3	4	5	6
8	8	9	0	1	2	3	4	5	6	7
9	9	0	1	2	3	4	5	6	7	8

DIAGNOSTIC TABLE: DISPLAY DRIVER MODULE, A1
REPAIR LEVEL: COMPONENT REPLACEMENT (Cont'd.)

CAUSE PROCEDURE

SYMPTOM VIII. Arcing Between Digits.

- A) Defective Zener Diode VR1
Measure voltage across Zener Diode. If voltage is 190 VDC or 0 VDC, replace zener, retest module.
- B) Defective Display Panel
If voltage is 110 ± 11 VDC, replace display panel. Retest module.

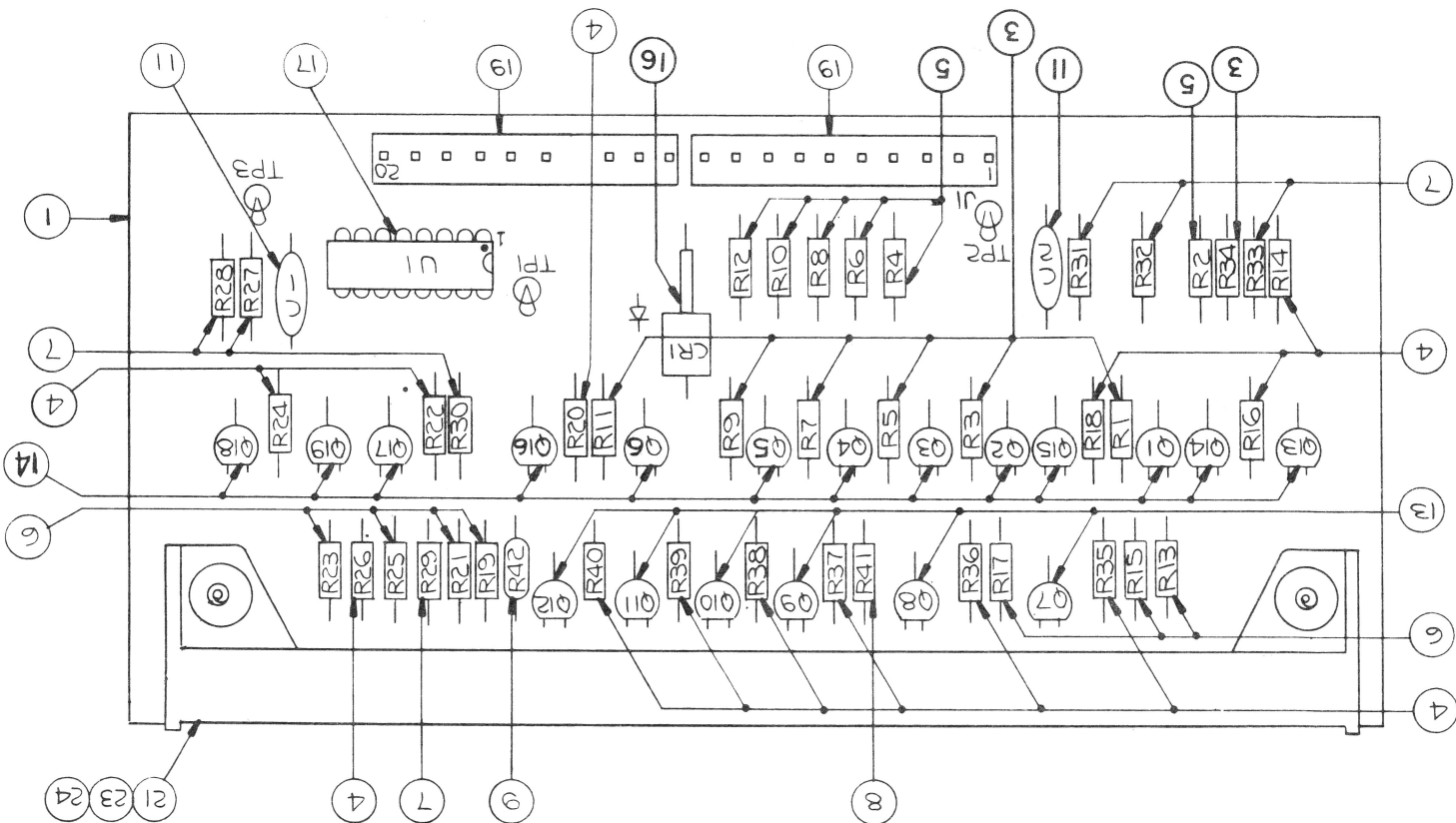
SYMPTOM IX. MPU does not flash LED on Power-up.

- Short on +5 VDC line
Remove C1 from Module. Test with Ohmmeter.
- A) Defective capacitor
If defective, discard. Replace C1, retest module.
- B) Defective Integrated Circuit U1
If good, return C1 to module. Replace integrated circuit U1. Retest module.

SYMPTOM X. MPU flashes LED once, briefly, on power-up. Game ready condition cannot be attained.

Short on address line
Disconnect connector J1. Power-up game. Use AID1. Carefully reconnect connector J1. Go to Symptom VI.

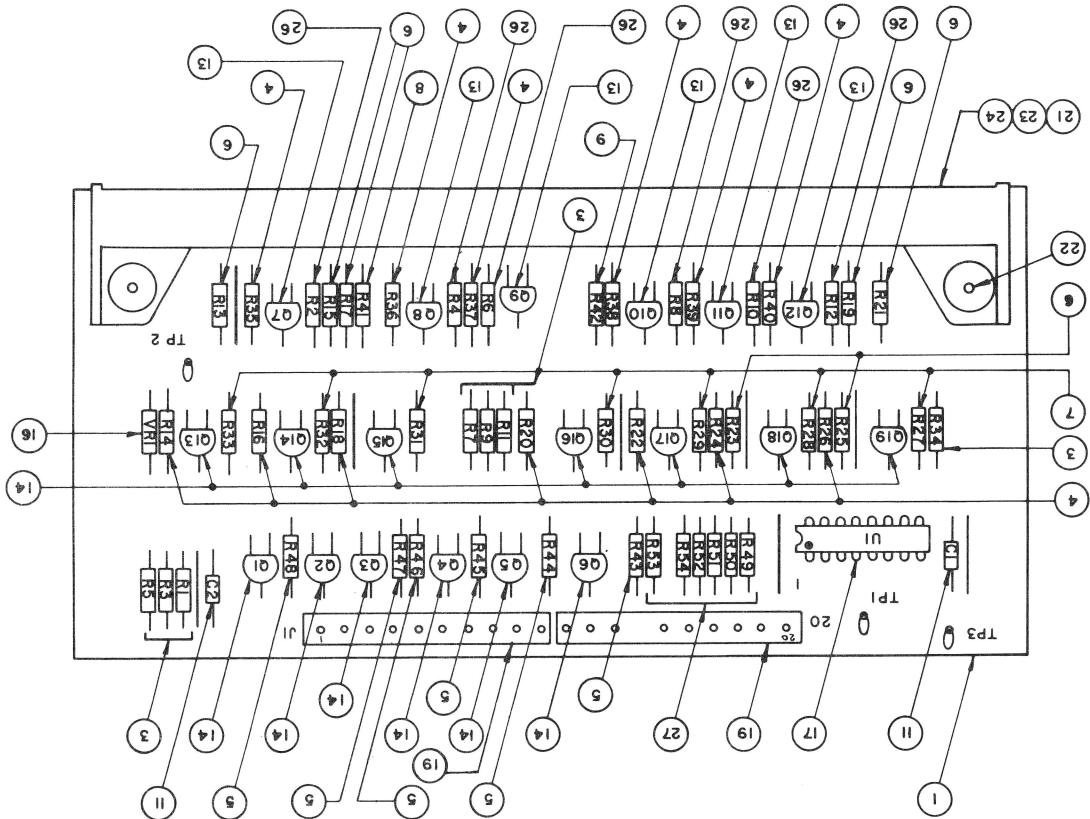
AS-2518-15 DISPLAY DRIVER MODULE



A1: DISPLAY DRIVER MODULE COMPONENT PARTS LIST

ITEM	REFERENCE	BALLY PART #	DESCRIPTION
1	A1	AS-2518-15	Display Driver Module, Complete
3	R1, R3, R5, R7, R9, R11, R14, R16, R18, R20, R22, R24, R26, R35-R40	E-00105-0226	Resistor, 100K, 1/4W
4	R2, R4, R6, R8, R10, R12, R13, R15, R17, R19, R21, R23, R25	E-00105-0227	Resistor, 300K, 1/4W
5	R2, R4, R6, R8, R10, R12, R13, R15, R17, R19, R21, R23, R25	E-00105-0228	Resistor, 9.1K, 1/4W
6	R13, R15, R17, R19, R21, R23, R25	E-00105-0229	Resistor, 1.5K, 1/4W
7	R27-R33	E-00105-0230	Resistor, 1K, 1/4W
8	R41	E-00105-0231	Resistor, 39K, 1/4W
9	R42	E-00105-0271	Resistor, 240K, 1/4W
11	C1, C2	E-00586-0065	Capacitor, .01 MFD, 500V
13	Q7-Q12	E-00585-0032	Transistor, 2N5401
14	Q1-Q6, Q13-Q19	E-00585-0033	Transistor, MPS-A42
16	CR1	E-00598-0007	Zener Diode, 110V, 1W
17	U1	E-00620-0038	I.C. Decoder, 14543B
19	J1, J2	E-00715-0034	10 Pin Water Connector
21	DS1	E-00680	Digital Display Panel
23		P-02399	Display Mounting (Top)
24		P-02399-0001	Display Mounting (Bottom)

AS-2518-21 DISPLAY DRIVER MODULE



A1: DISPLAY DRIVER MODULE COMPONENT PARTS LIST

ITEM	QTY.	REFERENCE	PART #	DESCRIPTION
1	1	P-2948-296	P.C. Board, M-645-392	
3	7	E-105-226	Resistor, 100K Ω	
4	13	E-105-227	Resistor, 300K Ω	
5	6	E-105-228	Resistor, 9.1K Ω	
6	7	E-105-229	Resistor, 1.5K Ω	
7	7	E-105-230	Resistor, 1K Ω	
8	1	E-105-231	Resistor, 39K Ω	
9	1	E-105-271	Resistor, 240K Ω	
10	2	E-586-65	Capacitor, .01 MFD	
11	6	E-585-32	Transistor (2N5401)	
13	6	E-585-33	Transistor (MPS-A42)	
14	13	E-598-7	Zener Diode, 110V	
16	1	E-620-38	I.C. Decoder	
17	1	E-715-34	10 Pin Wafer Pin Connector	
19	2	E-680	Digital Display Panel	
21	1	M-1836	Hi-Lo Screw, W/H	
22	2	P-2399	Display Mounting (Top)	
23	1	P-2399-1	Display Mounting (Bottom)	
24	1	E-105-287	Resistor, 2.2K Ω	
26	6	E-105-242	Resistor, 20K Ω	
27	6		Wire Jumper	
28	As Req'd			

NOTE: INTERCHANGEABLE WITH AS-2518-15

SOLENOID DRIVER/VOLTAGE REGULATOR MODULE A3

INDEX

PROCEDURAL STEPS

Page 52	+ 5 VDC Regulator related problems
Page 53	+ 190 VDC Regulator related problems
Page 54	Solenoid Driver related problems

I. High voltages are present in the + 190 VDC regulator circuit on the module. Exercise due caution when servicing.

II. Damage can result to the MPU module due to improper operation in the + 5 VDC regulator circuit. Disconnect MPU module connector J4 before turning on power to test Solenoid Driver/Voltage Regulator module. If voltage at TP1 is correct (+ 5 \pm .25 VDC), connector on MPU module may be connected. If voltage at TP1 is incorrect, leave MPU module connector off until proper operation is attained.

III. The Solenoid Driver module part of the Self-Test energizes each of the nineteen solenoid driver output circuits on the module. The game used as a test bed, however, may not have a solenoid assigned to each of the output circuits. If it does not, the following procedure can be followed:

A) Use the Solenoid Driver module part of the Self-Test. If faults are found, use the symptoms to select a repair procedure. Restore the module to operating condition by following the procedure.

B) Use the test bed game schematic. Make a list of the Solenoid Driver circuits that did not have Solenoid loads.

C) The LED on the MPU module is used as a substitute for a solenoid load. If the circuit under test is good, the LED can be made to flash on and off in the test bed game. Access to the collector of the first solenoid driver transistor on the list is available at J1, J2, J3 or J5. Refer to the Solenoid Driver module schematic. Insert a 3/4" piece of solid wire (ex: a resistor lead clipping) into the connector contact position to be tested. Connect a test lead from TP6 on the MPU module to the piece of wire.

D) Repeat A.
E) Repeat C and A for each of the remaining Solenoid Driver circuits on the list. Return the module to stock or repair, as required.

IV. Solenoid Bank Extender modules can be tested in the test bed game.

If the game has provision for a Solenoid Bank Extender insert the module in its proper place and conduct the Solenoid Driver module part of the Self-Test. The procedure above must be followed to test unused outputs. If the Game does not have provision for a Solenoid Bank Extender module, insert it in the Solenoid Driver position. Connect J4, cable harness to J4 on the module, J2 to J2. Testing is the same as for the game with provision for the module. Unused outputs are also to be tested. Solenoid assignments are given on the test bed game Solenoid Driver module schematic.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR* MODULE, A3 REPAIR LEVEL: COMPONENT REPLACEMENT, + 5 VDC REGULATOR CIRCUIT

CAUSE	PROCEDURE
-------	-----------

SYMPTOM I. * No regulation. Input TP5 and output TP1 are equal (+ 11.9 VDC).

Defective integrated circuit Q20	* Replace Q20, voltage regulator. Measure voltage at TP1. If + 5 ± .25 VDC, replace MPU module connector. Retest module.
----------------------------------	--

SYMPTOM II. No output at TP1. TP5 normal (11.9 VDC).

A) Defective capacitor C36	Remove connector contact, J3, pin 25. If TP1 is + 5 ± .25 VDC, replace C22, .01 Mf, reinsert contact, retest module.
B) Defective integrated circuit Q20	If TP1 is 0 VDC, replace Q20, retest module.
C) Defective capacitor C25	If TP1 is still 0 VDC, replace capacitor C25, 0.1 Mf, retest module. Q20, replaced in step "B," may be retested and, if good, returned to stock.

SYMPTOM III. Module blows fuse F6 on transformer module.

A) Defective capacitor C23	Disconnect one lead of capacitor C23, 11,700Mf. Discharge capacitor with screw driver. With ohmmeter set to Rx 100, capacitor takes about 50 seconds to charge (0-∞). If capacitor reads short after 50 seconds, replace and retest module.
B) Defective capacitor C24	If C23 checks good, unsolder one lead of C24, 2Mf. Discharge capacitor with screw driver. With Ohmmeter set to Rx 10,000, capacitor reads about 100,000 ohms. If capacitor reads short, replace and retest module.
C) Defective integrated circuit Q20	If capacitor is good, resolder. Replace Q20, retest module.

SYMPTOM IV. MPU module does not flash LED, play tune on power-up.

A) Defective capacitor C23	Disconnect one lead of capacitor C23, 11,700Mf. Discharge capacitor with screw driver. With ohmmeter set to Rx 100, capacitor takes about 50 seconds to charge (0 to ∞).
B) Defective integrated circuit Q20	If capacitor charges rapidly, replace and retest module. If C23 checks good, reconnect lead. Replace Q20. Retest module.

* Disconnect MPU module connector J4 before testing module. Turn on power. If voltage at TP1 is greater than + 5 VDC, correct problem before connecting MPU module connector. Failure to observe this procedure can result in damage to MPU module.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3
REPAIR LEVEL: COMPONENT REPLACEMENT, + 190 VDC REGULATOR CIRCUIT

PROCEDURE

CAUSE

SYMPTOM I. $V_{IN}(TP4) = V_{OUT}(TP2)$.

- At cathode of zener diode VR1 (wiper on pot) measure: 140 ± 14 VDC, If voltage is present, but high, use ohmmeter to determine condition of zener diode.
- A) Defective Zener, overheated resistors
- B) Defective pot
- C) Defective transistor Q23
- If voltage at base is 0 VDC, and R55 (1.2k Ω) is good, replace Q23, retest module.
- If voltage at base is 1.5 VDC (approx.) or if R55 is open, measure voltage at collector of Q23.
- If voltage is 230 VDC, disconnect all display driver modules.
- CAUTION: Failure to do so can damage Q21, Q22. Use jumper to short Q23 collector to ground, measure voltage at TP2. Remove jumper quickly to prevent damage to R7 (22k Ω).
- If voltage at TP2 went to 0 VDC, and returned to 234 VDC, replace Q23. Retest module.
- If fuse blew, unsolder and lift one end of C27. Check C27 with ohmmeter.
- E) Shorted capacitor C27
- F) Defective transistors Q21, Q22 and Q23
- Replace Q21, Q22, Q23, R55 and fuse and retest module.
- If C27 is good, resolder C27.
- If fuse did not blow, unsolder one lead of diode CR21. Measure CR21 diode with an ohmmeter, both directions.
- G) Defective diode CR21, transistors Q21, Q22, Q23
- H) Defective transistors Q21 and Q22

SYMPTOM II. $V_{OUT}(TP2) = 20$ VDC or less.

- A) Defective Zener diode VR1
- At wiper on pot (cathode of zener diode VR1) measure 140 ± 14 VDC. If voltage is absent, check zener diode with an ohmmeter.
- If zener is shorted, replace zener. If R58 (8.2k Ω) and pot are damaged, replace. Retest module.
- If zener diode is good, measure voltage at collector of Q23: 193 VDC. If voltage is 1.5 VDC, disconnect one end of C28. Check C28 with ohmmeter.
- B) Defective capacitor C28
- C) Defective transistor Q23
- D) Defective transistors Q21 and Q22
- If C28 is good, replace transistor Q23 and R7 (22k Ω). Retest module.
- If voltage at collector, Q23 is correct, replace transistors Q21 and Q22. Retest module.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3
REPAIR LEVEL: COMPONENT REPLACEMENT, + 190 VDC REGULATOR CIRCUIT (Cont'd.)

CAUSE	PROCEDURE
-------	-----------

SYMPTOM III. Vin out of limits, below 206 VDC.

Defective capacitor C26, 160Mf, 350 WVDC	Replace capacitor. Retest module.
--	--------------------------------------

SYMPTOM IV. Module blows fuse.

Defective capacitor C26, 160Mf, 350 WVDC	Replace capacitor. Retest module.
--	--------------------------------------

SYMPTOM V. Vout (TP2) = 190 VDC; Vout, J3, Pin 8 = 0 VDC; AS-2518-22 only.

Blown Fuse	Replace fuse F1 (Bally Part #E-133-30, 1/4-A Fast Bio).
------------	---

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3
REPAIR LEVEL: COMPONENT REPLACEMENT, SOLENOID DRIVER CIRCUITS

CAUSE	PROCEDURE
-------	-----------

SYMPTOM I. Solenoid does not pull-in.

A) Defective Solenoid Driver Transistor	Use jumper to connect TP6 pull-up resistor (120 Ω) to base of solenoid driver transistor (Ex: Q2). If solenoid pulls-in, go to Step I-C).
B) Lack of continuity	If solenoid does not pull-in, use voltmeter at transistor collector. If meter reads 43 ± 5.4 VDC, replace solenoid driver transistor. Retest module.
C) Defective Integrated Circuit U1, U3, U4	Use jumper to ground the base of transistor driver (U1, U3 or U4, as appropriate). If solenoid does not pull-in, measure voltage (DC) at collector-diode junction, transistor driver. If voltage at collector is 0 VDC, replace U1, U3 or U4 as appropriate. Retest module.
D) Defective diode (Open)	If solenoid does not pull-in and voltage at collector is 5 VDC, replace diode (Ex: CR2), retest module.
E) Lack of continuity (Solenoids not driven from U2)	If solenoid pulls-in and is not associated with U2 determine reason for lack of continuity to input connector J4. Repair, retest module.
F) Defective integrated Circuit U2	If solenoid pulls-in and is associated with U2, replace U2. Retest module.

SYMPTOM II. Solenoid always energized.*

A) Defective solenoid driver transistor	Ground base of solenoid driver transistor (Ex: Q2). If solenoid remains energized, replace solenoid driver transistor. Retest module.
B) Defective diode (Shorted)	Measure voltage at base of solenoid driver transistor.
C) Lack of continuity	If 0.3 VDC, replace diode, retest module. If .7 to 1.4 VDC, use jumper to connect TP7 pull-up resistor (1.2k Ω) to base of transistor driver (U1, U3 or U4 as appropriate). If solenoid de-energizes for transistor drivers not connected to U2 determine reason for lack of continuity between 3.9k Ω pull up resistor and + 5 VDC. Repair, retest module.

* Solenoids associated with 1 of 16 decoder U2 are designed for impulse operation only and may become damaged if operated continuously.

DIAGNOSTIC TABLE: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE, A3

REPAIR LEVEL:

COMPONENT REPLACEMENT, SOLENOID DRIVER CIRCUITS

CAUSE

PROCEDURE

SYMPTOM II. Solenoid always energized.* (Cont'd.)

- | | |
|--|--|
| D) Defective integrated circuit U1, U3, U4 | If solenoid remains energized, replace integrated circuit U1, U3 or U4 as appropriate. Retest module. |
| E) Lack of continuity | If solenoid remains energized for transistor drivers associated with U2 replace integrated circuit U1, U3 or U4 as appropriate. Retest module. |
| F) Defective integrated circuit U2 | If solenoid de-energized, remove jumper. Remove input connector. Measure + 5 VDC at U2 pins 20-23 incl. If voltage not present, determine reason for lack of continuity between 100k Ω pull-up resistor and + 5 VDC. Repair, retest module. |
| G) Defective integrated circuit U2 | If + 5 VDC is present at inputs, replace U2. Repair, retest module. |

SYMPTOM III. U2 associated solenoids:

1/2, 1/4, 1/8 or one always energized. 1/2, 1/4, 1/8 or non energized.

- | | |
|------------------------------------|---|
| A) Defective integrated circuit U2 | Use AID1. Probe inputs at U2, pins 20-23 incl. If LED lights, replace U2. Retest module. |
| B) Lack of continuity | If LED does not light, use probe at J4, pins 3, 4, 5 and 6. If LED lights, find reason for lack of continuity to U4. Repair, retest module. |
| C) Defective integrated circuit U2 | If LED does not light, replace U2. Retest module. |

SYMPTOM IV. All solenoids de-energized.

- | | |
|-----------------------|--|
| A) Lack of continuity | Use Voltmeter to find reason for lack of continuity to + 5 VDC supply line. Repair, retest module. |
|-----------------------|--|

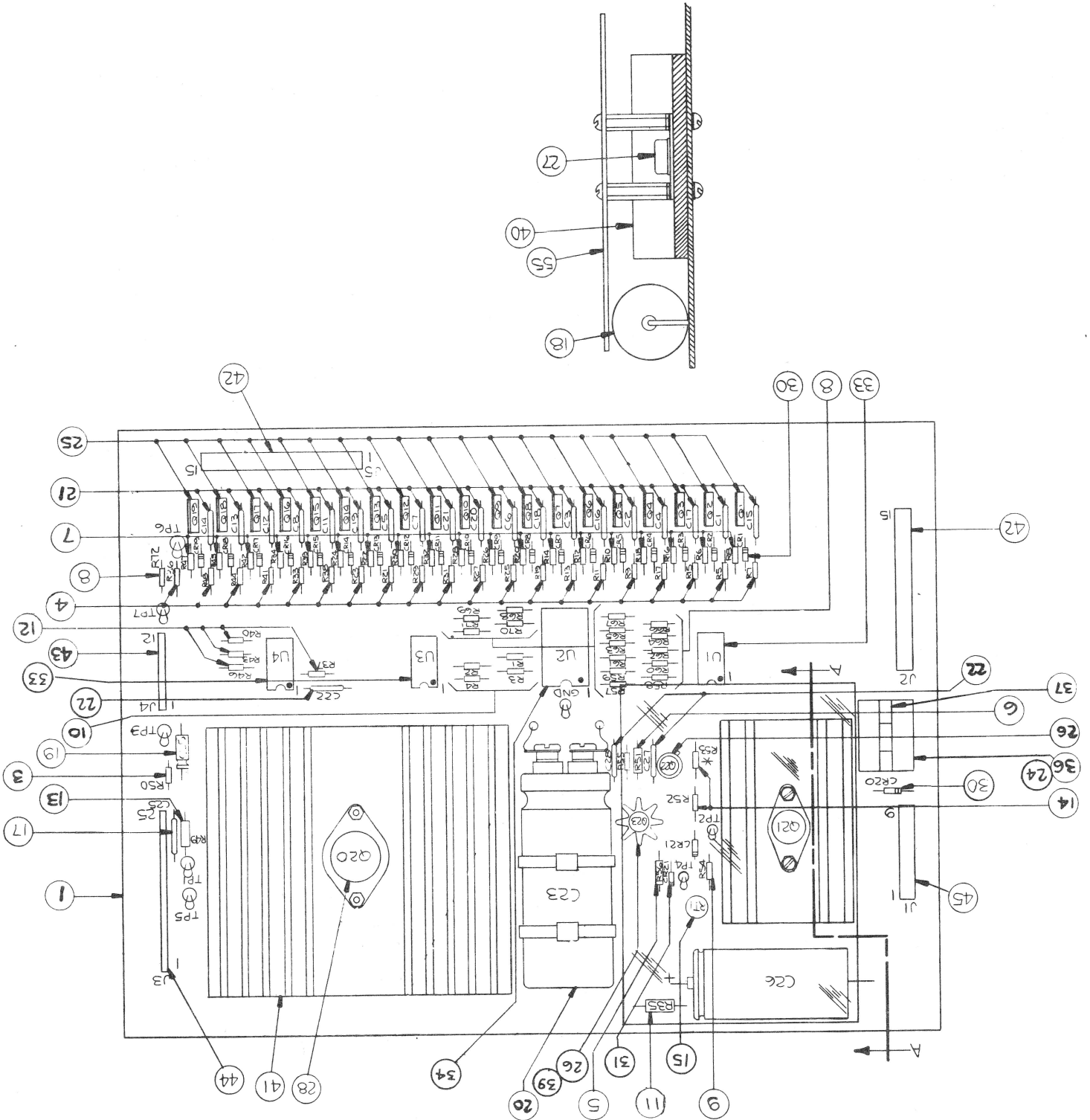
SYMPTOM V. MPU does not flash LED on Power-up.

- | | |
|--|--|
| Short on + 5 VDC line | Remove contact from connector J3, pin 25. |
| A) Defective capacitor C22 | If 5 VDC is present at TP1, remove C22. Test with ohmmeter. |
| B) Defective integrated circuit U2 | If defective, discard. Replace C22, reinsert contact, connector J3. Retest module. |
| C) Defective + 5 VDC Voltage Regulator | If C22 is correct, replace integrated circuit U2. |

If + 5 VDC is not present, proceed to Voltage Regulator Diagnostic Table.

* Solenoids associated with 1 of 16 decoder U2 are designed for impulse operation only and may become damaged if operated continuously.

AS-2518-16 SOLENOID DRIVER/VOLTAGE REGULATOR MODULE



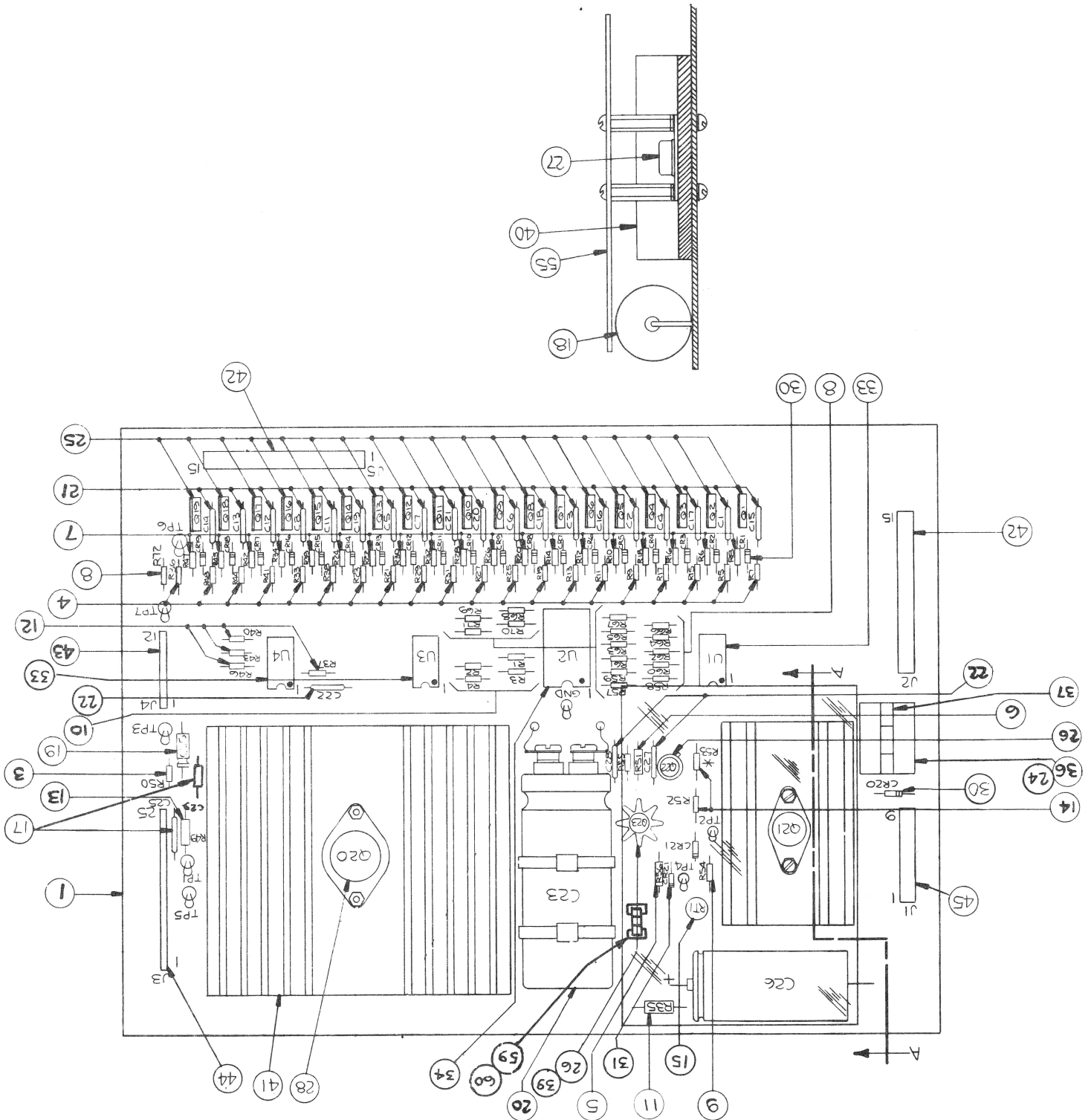
A3: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	A3	AS-2518-16	Solenoid Driver/Voltage Regulator Module, Complete
3-14	Resistors		Resistor, See Schematic for value.
15	RT1	E-00599-0014	Pot. (Linear) 25K
17	C25	E-00586-0014	Capacitor, 1 MFD, 20V
18	C26	E-00586-0059	Capacitor, 160 MFD, 350V
19	C24	E-00586-0063	Capacitor, 2 MFD @ 25V
20	C23	E-00586-0062	Capacitor, 11700 MFD, 20V
21	C1-C8, C11-C21	E-00586-0064	Capacitor, 002 MFD, 1kv
22	C22, C27, C28	E-00586-0065	Capacitor, .01 MFD, 500V
24	K1	E-00146-0791	Relay
25	Q1-Q19	E-00585-0034	Transistor, SE9302
26	Q22, Q23	E-00585-0041	Transistor, 2N3440
27	Q21	E-00585-0042	Transistor, 2N3584
28	Q20	E-00710	+5V Regulator, LAS1405 or 78H05KC or LM323K
30	CR1-CR21	E-00587-0015	Diode (IN4004)
31	VR1	E-00598-0010	Diode, Zener 140V, IN5275A
33	U1, U3, U4	E-00681	I.C. Transistor Array, CA3081
34	U2	E-00620-0039	I.C. Binary to 1/16 Decoder, 74L154
36		E-00592-0002	Relay Socket
37		M-1839	Relay Holder
39		E-00682	Heat Sink, TO18
40		E-00682-0001	Heat Sink, TO66
41		E-00682-0002	Heat Sink, TO3 Case
42		E-00715-0039	15 Pin Water Connector
43		E-00715-0016	12 Pin Water Connector
44		E-00715-0020	25 Pin Water Connector
45		E-00715-0033	9 Pin Water Connector
55		M-1837	Shield-Plexiglass

REF: Page 56, parts location.

AS-2518-22 SOLENOID DRIVER/VOLTAGE REGULATOR MODULE

NOTE: INTERCHANGEABLE WITH AS-2518-16



A3: SOLENOID DRIVER/VOLTAGE REGULATOR MODULE

COMPONENT PARTS LIST

ITEM	REFERENCE	BALLY PART #	DESCRIPTION
1	A3	AS-2518-22	Solenoid Driver/Voltage
3-14	Resistors		Regulator Module, Complete Resistor, See Schematic for value.
15	RT1	E-00599-0014	Pot. (Linear) 25K
17	C25, 29	E-00586-0014	Capacitor, .1 MFD, 20V
18	C26	E-00586-0059	Capacitor, 160 MFD, 350V
19	C24	E-00586-0063	Capacitor, 2 MFD @ 25V
20	C23	E-00586-0062	Capacitor, 11700 MFD, 20V
21	C1-C8, C11-C21	E-00586-0064	Capacitor, .002 MFD, 1kV
22	C22, C27, C28	E-00586-0065	Capacitor, .01 MFD, 500V
24	K1	E-00146-0795	Relay, Printed Circuit
25	Q1-Q19	E-00585-0034	Transistor, SE9302
26	Q22, Q23	E-00585-0041	Transistor, 2N3440
27	Q21	E-00585-0042	Transistor, 2N3584
28	Q20	E-00710	+5V Regulator, LAS1405 or 78H05KC or LM323K
30	CR1-CR21	E-00587-0015	Diode (1N4004)
31	VR1	E-00598-0010	Diode, Zener 140V, IN5275A
33	U1, U3, U4	E-00681	I.C. Transistor Array, CA3081
34	U2	E-00620-0039	I.C. Binary to 1/16 Decoder, 74L154
36		E-00592-0002*	Relay Socket
37		M-1839*	Relay Holder
39		E-00682	Heat Sink, TO5
40		E-00682-0001	Heat Sink, TO66
41		E-00682-0002	Heat Sink, TO3 Case
42		E-00715-0039	15 Pin Water Connector
43		E-00715-0016	12 Pin Water Connector
44		E-00715-0020	25 Pin Water Connector
45		E-00715-0033	9 Pin Water Connector
55		M-1837	Shield-Plexiglass
59		E-00148-0021	Fuse Clips
60	F1	E-00133-0030	Fuse 8 AG-1/4 Amp.

*USED WITH ITEM 24, E-00146-0791, PLUG IN RELAY ONLY
REF: Page 58, Parts Location.

POWER TRANSFORMER MODULE A2 PROCEDURAL STEPS

POWER TRANSFORMER MODULE A2 PROCEDURAL STEPS

DIAGNOSTIC TABLE: POWER TRANSFORMER MODULE, A2
REPAIR LEVEL: COMPONENT REPLACEMENT

CAUSE PROCEDURE

SYMPTOM I. Output voltage(s) out of limits.

Measure at: TP1 5.4 \pm .8 VDC
TP2 230 \pm 27.4 VDC
TP4 7.3 \pm .9 VAC
TP5 43 \pm 5.4 VDC
TP3 11.9 \pm 1.4 VDC

Measure at: J2-6 to 7, line voltage \pm 10%.

A) Improper line voltage
If line voltage exceeds the \pm 10% limit, a variac can be used to adjust the input line voltage during the module test.

B) AC input jumpering not compatible with line voltage
If voltage(s) at test points are still out of limits, examine AC input jumpers. Determine if connections are proper for line voltage at test site. (see card in back box). Rearrange if necessary.

C) Defective bridge rectifier
If voltage at test point is low and out of limits, change bridge rectifier, retest module.

D) Lack of continuity
If still out of limits, change transformer. Retest module.
If voltage at test point is high and out of limits, determine reason for lack of continuity to output connector. Repair, retest module.
E) Defective transformer
If voltage at TP4 is out of limits, change power transformer. Retest module.

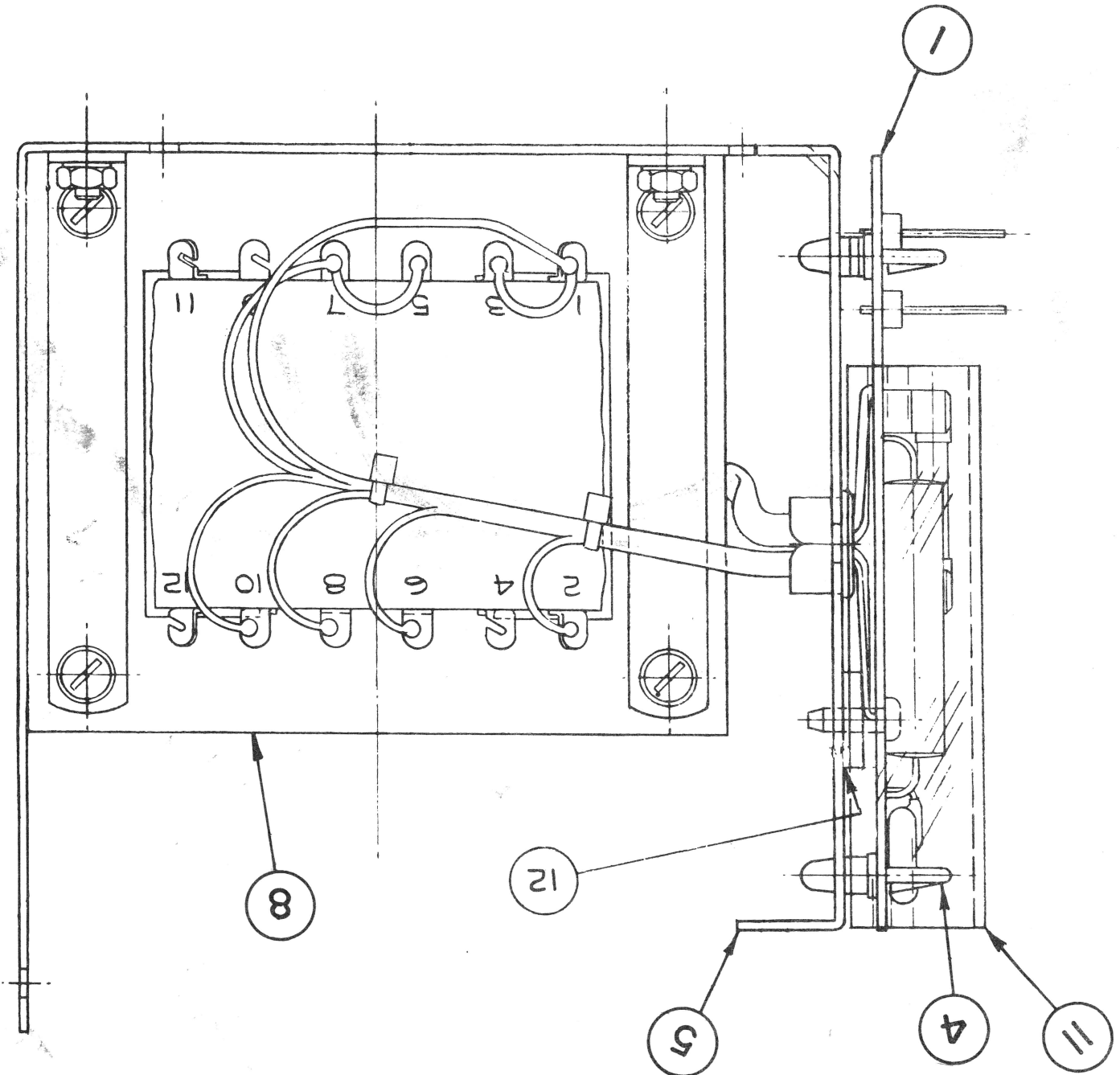
SYMPTOM II. Module blows fuse.

If module always blows input fuse F6, momentarily short across fuse holder (about 3 seconds).

A) Defective bridge rectifier
If fuse F1, 2, 3 or 4 blows, change associated bridge rectifier, retest module.
B) Defective Power Transformer
If no fuses blow, replace power transformer. Retest module.

A2: POWER TRANSFORMER MODULE COMPONENT PARTS LIST

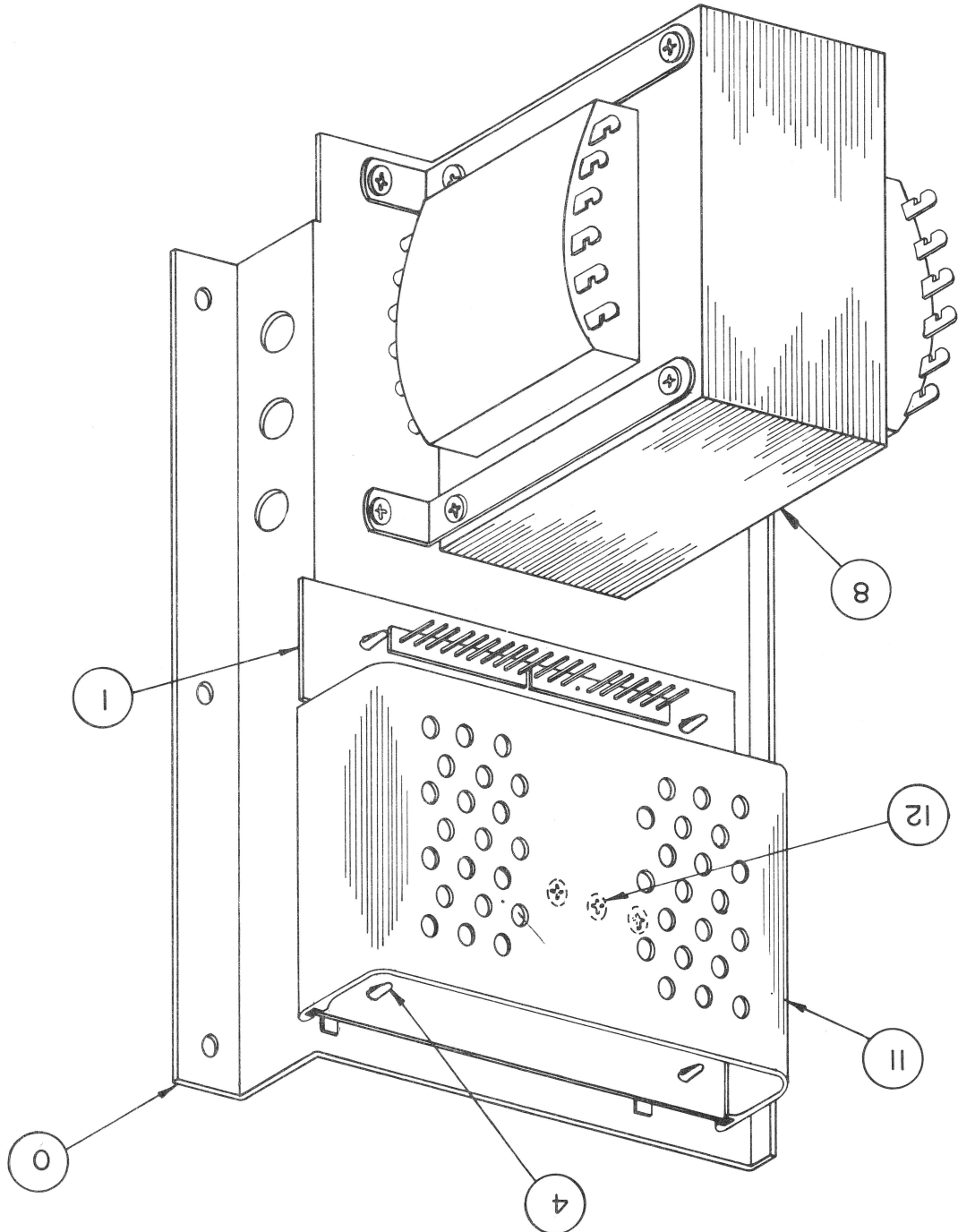
ITEM	REFERENCE	PART #	DESCRIPTION
0	A2	AS-2877	Power Transformer Module, Complete
1		AS-2518-18	Rectifier Board Assembly
4		M-1829a	Circuit Board Support
5		A-3840b	Mounting Plate & Stud Assembly
8		E-00122-0125c	Transformer 120/240V, 50/60 Hz
11		P-2692b	P.C.B Cover
12		M-1834	Heat Sink Compound



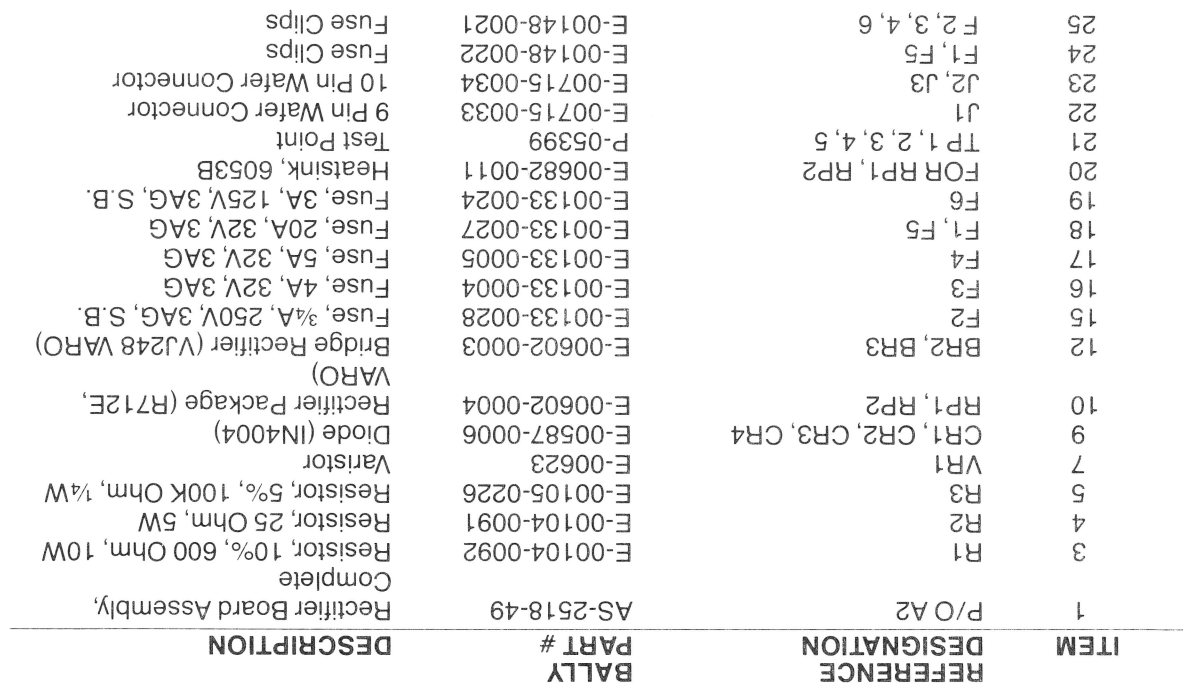
A2: POWER TRANSFORMER MODULE COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
0	A2	AS-2877-1	Power Transformer Module, Complete
1		AS-2518-18	Rectifier Board Assembly
4		M-1829-2a	Circuit Board Support (4 Req'd.)
8		E-00122-0125c	Transformer 120/240V, 50/60 Hz
11		P-2692b	P.C.B Cover
12		M-1834	Heat Sink Compound

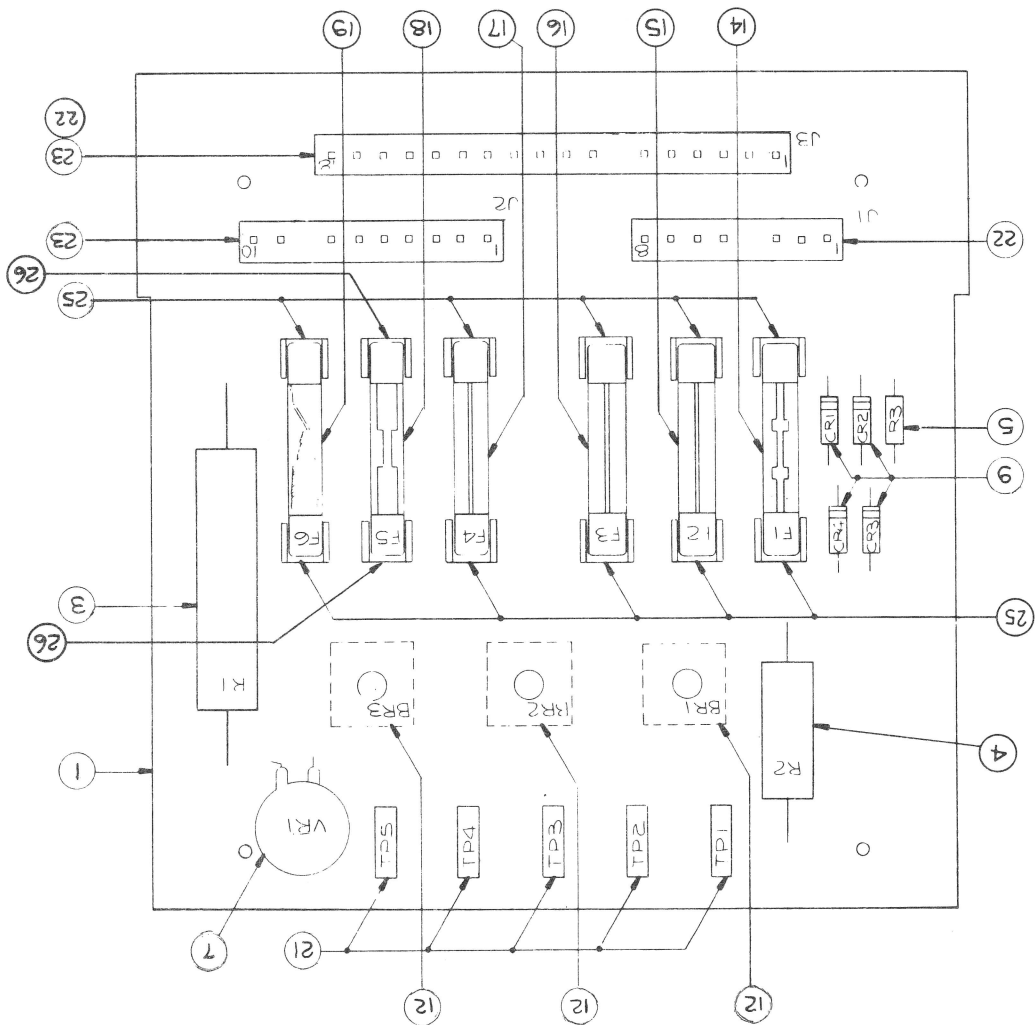
NOTE: RECOMMENDED REPLACEMENT FOR AS-2877



RECTIFIER BOARD ASSEMBLY
(Part of)
A2: POWER TRANSFORMER MODULE
COMPONENT PARTS LIST



AS-2518-18 RECTIFIER BOARD ASSEMBLY



RECTIFIER BOARD ASSEMBLY (Part of) A2: POWER TRANSFORMER MODULE COMPONENT PARTS LIST

ITEM	REFERENCE DESIGNATION	BALLY PART #	DESCRIPTION
1	P/O A2	AS-2518-18	Rectifier Board Assembly,
3	R1	E-00104-0092	Resistor, 10%, 600 Ohm, 10W
4	R2	E-00104-0091	Resistor, 25 Ohm, 5W
5	R3	E-00105-0226	Resistor, 5%, 100K Ohm, 1/4W
7	VR1	E-00623	Varistor
9	CR1, CR2, CR3, CR4	E-00587-0006	Diode (1N4004)
12	BR1, BR2, BR3	E-00602-0003	Bridge Rectifier (VJ248 VARO)
14	F1	E-00133-0010	Fuse, 10A, 32V, 3AG
15	F2	E-00133-0028	Fuse, 3/4A, 250V, 3AG, S.B.
16	F3	E-00133-0004	Fuse, 4A, 32V, 3AG
17	F4	E-00133-0005	Fuse, 5A, 32V, 3AG
18	F5	E-00133-0027	Fuse, 20A, 32V, 3AG
19	F6	E-00133-0024	Fuse, 3A, 3AG, S.B.
21	E-00684		Test Point
22	J1, J3	E-00715-0032	8 Pin Water Connector
23	J2, J3	E-00715-0034	10 Pin Water Connector
25		E-00148-0021	Fuse Clips
26		E-00148-0022	Fuse Clips

SOUND DRIVER MODULE A8 PROCEDURAL STEPS

Functionally, the Sound module is divided into six circuit areas, as follows:

1. Power Supply (Q1 and associated components).
2. Tone Data Processor (U2, P/O U1 and U3).
3. Programmable Frequency Generator (U13, U1C, U4, U5 and U11).
4. Tone Trigger Generator (U7, and associated circuitry).
5. Voltage Controlled Alternator (U8).
6. Audio Amplifier (U9 and U10).

The following outlines a simplified test sequence to aid in quick localization of a fault to one of these circuit areas. Once the area of the fault has been determined, use must be made of the referenced sections for a more detailed analysis.

Unless stated otherwise, all measurements are made with respect to TP2, the ground line of the Sound module.

1. POWER SUPPLY CHECK

Measure $+5 \pm 0.25$ VDC at TP1 and $+12.5 \pm 1.3$ VDC at TP3. If incorrect, go to Section I.

2. FREQUENCY GENERATOR CHECK

Measure $+0.8$ VDC at junction of R3 and R5. If incorrect, go to Section II.

3. AUDIO AMPLIFIER CHECK

Measure $+2$ VDC (approx.) at U9, pin 2. Observe that a ticking sound is produced each time U9, pin 2 is touched with meter test lead. If incorrect, go to Section III.

4. TONE TRIGGER GENERATOR CHECK

With the game in play mode, activate any playfield switch that will result in momentary solenoid (slingshot, etc.) activity. On the Sound module, connect a jumper from TP1 ($+5$ V) to U2, pin 5 (the junction of R24 and R28, see schematic). No sound should be heard, unless a playfield switch is activated.

If sound is heard with the jumper installed, refer to Sections V and II (in that order).

Activate a playfield switch. If sound is heard with jumper in place, but not without it, go to Section IV.

5. VOLTAGE CONTROLLED ATTENUATOR CHECK

Temporarily place a short between pins 1 and 2 of U8 on the Sound module and activate a playfield switch.

If sound is heard with the short installed, but not without it, refer to Section III.

If sound is not heard with the short in place, refer to Sections V and II (in that order).

DIAGNOSTIC TABLE:

SOUND DRIVER MODULE, A8

COMPONENT REPLACEMENT

POWER SUPPLY ASSOCIATED FAILURES

REPAIR LEVEL:

SECTION I:

CAUSE	PROCEDURE
-------	-----------

<p>SYMPTOM I: No Sound or distorted sound. TP1 (+5V) Voltage incorrect.</p> <p>A) Open + 5 VDC line Measure + 5 ± .25 VDC at TP1. If absent at A3-TP1, use standard troubleshooting techniques to locate and repair short on + 5 volt distribution circuit on Sound module. and TP1 on Sound module.</p> <p>B) Short on + 5 VDC line If absent at A3-TP1, use standard troubleshooting techniques to locate and repair short on + 5 volt distribution circuit on Sound module.</p>	<p>SYMPTOM II: No Sound or distorted sound. TP3 (12.5 ± 1.3 VDC) voltage low or absent.</p>
---	--

<p>A) Open + 43 VDC line Measure + 43 ± 5.4 VDC at TP4. If correct, proceed with C). If absent, measure + 43 volts at A2-TP5, Power Transformer module. If present at A2-TP5, locate and repair open between connector and TP4 on Sound module.</p> <p>B) Short on + 43 VDC line If absent at A2-TP5, use standard troubleshooting techniques to locate and repair short in + 43 volt circuit on Sound module. In particular, check for shorted capacitor C17 on the Sound module. With power off, connect positive lead of ohmmeter to TP3, negative to ground and measure resistance. The resistance should be in excess of 1k Ω (3k Ω typically). If low or shorted, use standard troubleshooting techniques to locate and repair the short on + 12 volt distribution circuit. NOTE: Short or low impedance circuit on + 12 volt line may result in damaged Q1 and CR4. It is therefore advisable to replace Q1 and CR4 after the short has been repaired.</p> <p>C) Short on + 12 volt line</p>	<p>D) Defective + 12V Regulator CR3 Open CR3 Shorted C17 Open</p>
---	---

<p>Measure voltage at collector of Q1. With no sound output (volume control all the way CCW) the collector of Q1 should be within a few volts of the voltage at positive terminal of C17. If the collector voltage is low or absent, check the following and replace defective components as necessary. a) Open or high resistance R36. b) Q1 collector to base short causing overload through CR4. c) Excessive current drain on + 12V line. If voltage at collector of Q1 is normal and the voltage at base of Q1 is + 13 ± 1.3 volts, replace Q1. If voltage at base of Q1 is low or absent, check for open R22 and replace if defective. If R22 is not defective, check for shorted CR4 or C18. If either is found defective, replace along with Q1. If voltage at base of Q1 is out of tolerance, replace CR4.</p>	<p>SYMPTOM III: No Sound or distorted sound. TP3 (+ 12.5 ± 1.3 VDC) voltage abnormally high.</p>
---	---

<p>R36 Open Q1 Shorted Overloaded + 12V line Q1 Open R22 Open CR4 Shorted C18 Shorted CR4 out of tolerance</p>	<p>Q1 Shorted CR4 Open R22 Shorted</p>
--	--

Check for shorted Q1, open CR4, and/or shorted R22.
If either is found defective, replace along with Q1 and CR4.
NOTE: Voltages higher than + 16V on the + 12V line may result in damage to IC's U7, U8, U9 and U10.

66

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: SECTION II: FREQUENCY GENERATION ASSOCIATED FAILURES

CAUSE	PROCEDURE
SYMPTOM I: No Sound. (Clock Signal failure).	
A) Clock generator U1B, Measure +2.5 VDC on U1B, pin 4. If correct, go to IIIB. If incorrect, replace U1.	
B) Clock generator component defective	If still incorrect after U1 replacement, check for defective clock generator components.
C) U4 defective	The fault may also be due to defective clock input line on U4. Replace as necessary.

SYMPTOM II: No Sound or incorrect tone sequence. (Frequency division failure)	
A) U4 and/or U5 defective U11 clock input line defective (Additional testing may be performed with the game operating in chime mode. In this case the signal at U11, pin 1 changes from 'null' condition square wave to a series of narrow pulses, and the voltage at U11, pin 1 is approximately +0.1 VDC). Measure +2.5 VDC at U11, pin 1. If correct, proceed with next step. If incorrect, replace U4, U5 and/or U11.	
B) U11 defective	Measure +2 VDC at pins 9 and 11 of U11. If incorrect, replace U11. Referring to the schematic, trace the signal from U11, pins 9 and 11 to U8, pin 2. Replace defective circuit components as necessary.
C) Waveshaping circuit defective	

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: SECTION III: COMPONENT REPLACEMENT
AMPLIFICATION ASSOCIATED FAILURES

CAUSE	PROCEDURE
SYMPTOM I: Activating a chime associated switch produces no sound, unless pins 1 and 2 of U8 on Sound modules are shorted.	
A) Sustain Adjust RT2 set incorrectly	With the short removed, check if the fault is not caused by improperly set sustain adjust (RT2). Readjust RT2 if necessary.
B) Tone trigger on envelope generator defective	If still incorrect, check for defective tone trigger and envelope generator function, as described under SYMPTOM IIA, Section IV.
C) U8 defective	If the trigger and envelope functions are normal, replace U8.

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: SECTION III:
AMPLIFICATION ASSOCIATED FAILURES (Cont'd)

CAUSE **PROCEDURE**

SYMPTOM II: No Sound or distorted sound. Frequency generator, tone trigger and envelope generator function normally.

- A) Volume control (RT3) Check if the fault is not caused by volume control set all the way CCW, or too far CW. Readjust RT3, if necessary.
- B) Defective loudspeaker If sound is absent, or distorted, check and replace the loudspeaker, if defective.
- C) Defective U10 If loudspeaker is not defective, replace U10. Also check U10 associated components and replace if defective.
- D) Defective U9 or volume control RT3 If sound is heard in Step B), but not without the jumper, replace U9. Also check volume control (RT3) and replace if defective.

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: SECTION IV:
COMPONENT REPLACEMENT
SECTION IV: TONE TRIGGER AND ENVELOPE GENERATING CIRCUIT
ASSOCIATED FAILURES

CAUSE **PROCEDURE**

SYMPTOM I: With U2, pin 5 jumpered to +5V (see test), sound function appears normal, except for short sustain duration. Sound sequences cannot be obtained without the jumper.

On the Sound module, connect a voltmeter to measure voltage at J1, pin 8. Connect a jumper from TP1 (+5V) to the junction of R24, R28 and U2, pin 5.

With the game in a state to accept a player and the ball in the outhole, press the player-up button. Observe that the voltage at J1, pin 8 is at a high level (approx. +4 VDC) when the player-up sound is heard, and then goes to a low level (approx. 0 VDC) as the outhole solenoid energizes. If voltage at J1, pin 8 of the Sound module is incorrect, investigate wiring on Sound module for a short to +43 VDC or ground line.

A) Solenoid Bank
 Select line fault

B) Defective U7
 or associated components

On the Sound module, remove the jumper from TP1 to U2, pin 5 and connect the voltmeter to measure trigger voltage at U7, pin 3. Observe that the trigger voltage changes from a low level (approx. 0 VDC) when no sound is played, to a positive value (single chime note will produce approx. 0.25 VDC peak reading, noise sequences may produce 6 VDC peaks), when a sound associated switch is activated. (Sound may not be heard at this point, however, the voltage should change as indicated.)

If trigger voltage is absent, replace U7 or associated components (Q2, etc.) as necessary. Retest. Proceed as in step B) above, except connect the voltmeter to measure voltage at U2, pin 5.

C) U2 clock input
 line defective

Observe that the voltage at U2, pin 5 changes from a low level (0 VDC) to approx. one-third the maximum value observed in step B), when the same sound associated switch is activated. If incorrect, check for open signal path from U7, pin 3 to U2, pin 5, including voltage divider R24 and R28. Repair if defective. Else, replace U2. Retest.

DIAGNOSTIC TABLE: SOUND DRIVER MODULE, A8
REPAIR LEVEL: COMPONENT REPLACEMENT
SECTION IV: TONE TRIGGER AND ENVELOPE GENERATING CIRCUIT
ASSOCIATED FAILURES (Cont'd)

CAUSE	PROCEDURE
-------	-----------

SYMPTOM II: Chime sound is absent or decays abnormally. Sustain adjust (RT2) does not function normally.

A) Defective envelope circuit components
 Observe that the voltage is at a low level (0 VDC) and momentarily increases to approx. +2.5 VDC when a single chime associated switch is activated. (Multiple chimers or noise sequences will cause higher peak readings.)
 If incorrect, refer to the schematic and check envelope circuit components CR1 through R11. Repair and retest.
 Refer also to step B) of SYMPTOM I.

B) Defective sustain adjust circuitry or defective U8
 age changes smoothly from 0 VDC with RT2 CCW to approx. +0.5 VDC with RT2 CW.
 If DC level at U8, pin 3 cannot be adjusted or changes abruptly when RT2 is rotated, change RT2. Retest.

U8, pin 3 input defective
 If voltage at U8, pin 3 is incorrect, refer to the schematic and check sustain circuitry from R11 to U8, pin 3, and R14 for defective components, solder splashes or otherwise abnormal conditions. Repair as required, else, replace U8. Retest.

U8 defective
 If voltage at U8, pin 3 is correct, disconnect voltmeter from U8, pin 3. (All jumpers should also be disconnected.) Set volume control (RT3) approx. 1/4 turn CW and activate a chime associated switch. Set Sustain Adjust (RT8) CW.
 If sound is heard, but sustain cannot be set for normal decay, replace U8. Retest.
 If sound is not heard with RT2 all the way CW, refer to Section III.

SECTION V
ZONE DATA BUS ASSOCIATED FAILURE PROCEDURE

PART I: TROUBLESHOOTING WITH AID1.

- 1) Turn off power. Install AID1 module on MPU connector J5. Clip AID1 test probe to TP1 of AID1. On the Sound module connect a jumper from TP1 (+5V) to the junction of R24, R28 and U2, pin 5.
- 2) Turn power ON and after game powers up, (power-up tune may not be heard with defective Sound module) initiate Self Diagnostic Test by pressing Self-Test switch button inside the cabinet door.
- 3) Enter AID1 program by pressing S33 on the MPU module.
- 4) Using AID1 test probe, examine the data lines at the points listed in Table I. Normal operation is indicated if the LED on the MPU module lights and any humming noise disappears each time a data line is probed. In this manner, the signal can be traced from its origin on the MPU module to the Sound Module Tone Memory U3.

If signal is not present at any of the test points of Table I, refer to the schematic and wiring diagrams to determine the defective components involved. Repair and retest.

SECTION V

STONE DATA BUS ASSOCIATED FAILURE PROCEDURE (Cont'd)

TABLE A8-1 TONE DATA BUS ASSOCIATED FAILURES

LINE UNDER TEST	MPU MODULE	SOUND MODULE
(Sol.) Address A	J4 - 4	J1- 1 U2- 4 U1- 2 U3-10
(Sol.) Address B	J4 - 3	J1- 2 U2- 7 U1-10 U3-11
(Sol.) Address C	J4 - 2	J1- 3 U2-13 U1-12 U3-12
(Sol.) Address D	J4 - 1	J1- 4 U2-14 U1-15 U3-13
Address E	J1 - 7	J1-12
Sol. Bank Select	J4 - 10	J1- 8

- 5) Remove jumper from TP1 to U2, pin 5 and measure 0 VDC (approx.) on U2, pin 5. If incorrect, refer to the schematic, determine the cause, and repair, replacing U2 if necessary. Retest.

PART II: TROUBLESHOOTING WITHOUT THE USE OF AID

If AID1 module is not available or if the AID1 tests do not locate the problem, the operation of the Sound module Address Data Latch (U2) and Tone Memory (U3) can be checked with the use of jumper leads and a voltmeter. The jumper leads are needed to simulate and clock-in desired address signals, while the voltmeter is used to observe if correct logic signal levels are present.

- 1) Place the game in normal operating mode (not in Self-Diagnostic Test). Do not operate any playfield switches.

- 2) Check that address input signals at Sound module connector J1, pins 1, 2, 3 and 4 are all high (approx. 4 volts).

- 3) Clock-in and latch the address signal (address lines all high). This is accomplished by momentarily connecting a jumper on the Sound module from TP1 (+5V) to the junction of R24, R28 and U2, pin 5. Latching occurs on the high to low transition of the clock signal (simulated by the jumper).

With the jumper removed, measure 0 VDC (approx.) on U2, pin 5. If incorrect, refer to the schematic, determine the cause and repair, replacing U2 if necessary. Retest.

If U2 output data at pins 3, 9, 12 and 15 are not the inverse of the latched address data, replace U2. If fault persists, replace U1.

If U2 outputs are correct, but U3 inputs at pins 10, 11, 12 and 13 are not, replace U3 and/or U1. If U3 inputs are correct, but its outputs at pins 1, 2, 3, 4, 5, 6, 7 and 9 are not, replace U3. If problem persists, check for line loading by U4 and/or U5, replacing same if necessary.

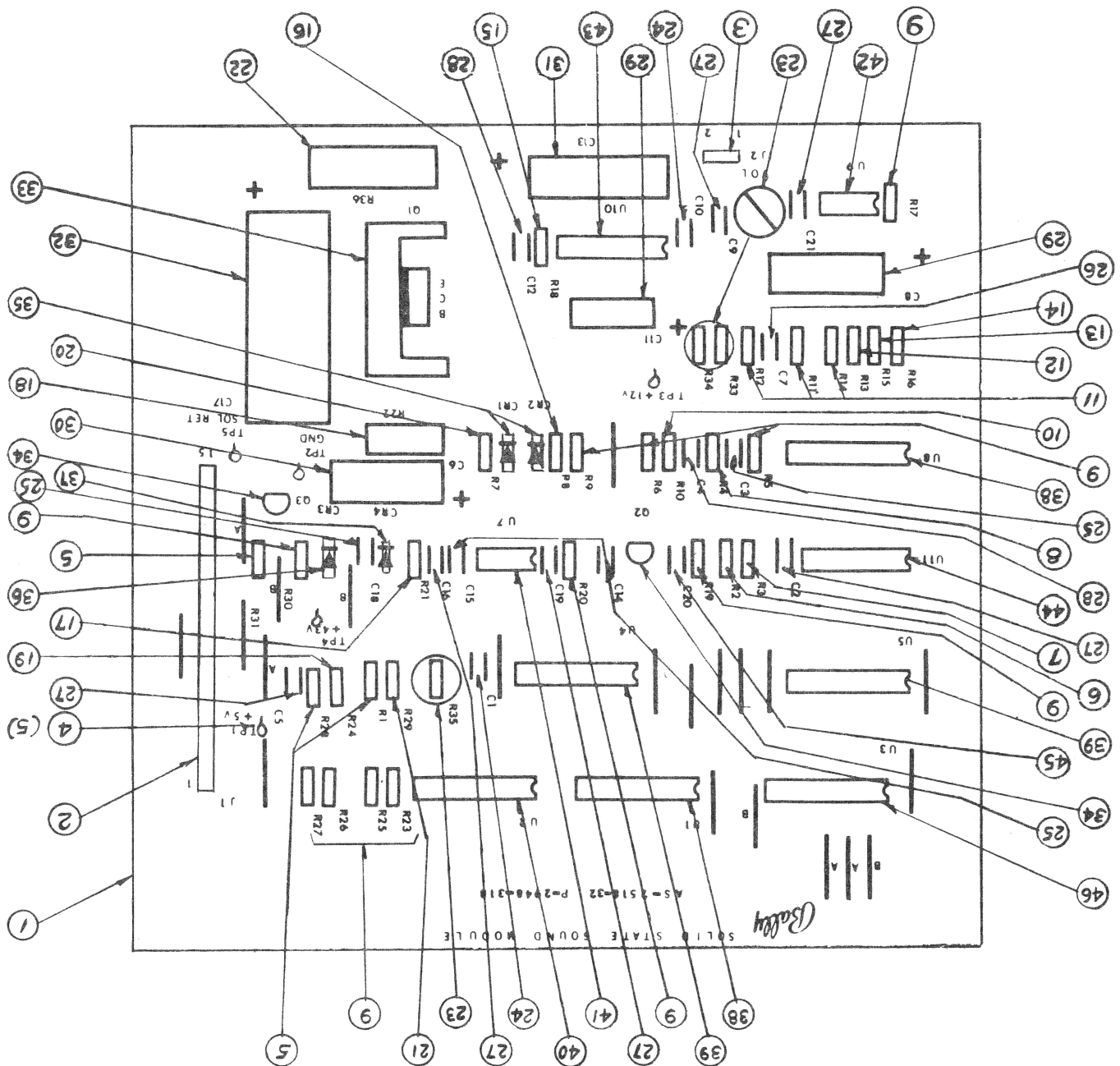
- 4) Proceed as above to clock-in and latch other address data combinations listed in Table A8-11. Examine, if correct logic levels are present. Replace defective components as required.

To simulate low address signals on lines A, B, C and D, connect jumpers from Sound module TP2 (+5V GND) to those U2 data inputs (pins 4, 7, 13, 14) for which the low address is required. With the "Address Jumpers" in place, clock-in and latch the data by momentarily connecting a jumper from TP1 (+5V) to U2, pin 5. Remove this jumper first, and then all address jumpers.

Address E signal is not latched in the Sound module, but is held by the MPU at either a high or a low level, depending on the last sound sequence. On the Sound module, the original is inverted by Q3 and then applied to U3, pin 14. Table A8-11 references this signal as seen at U3, pin 14. To change the signal from high to low, connect a jumper from TP2 (+5V GND) to U3, pin 14. To change from low to high, connect a jumper from TP2 to base of Q3. (Leave this jumper connected when the state of the address E signal must be altered.)

[illegible]

AS-2518-32 SOUND MODULE



A8: SOUND MODULE COMPONENT PARTS LIST

ITEM	REFERENCE	PART #	DESCRIPTION
1	A8 (see note 1)	AS-2888-1	PWB Module Complete—
2	J1	E-00715-0039	15 Pin Connector
3	J2	E-00715-0026	2 Pin Connector
4	TP1-TP5	P-05399	Test Clip
5	R1, R28, R31	E-00105-0239	Resistor 1/4W 5% 4.7K
6	R2	E-00105-0281	Resistor 1/4W 5% 15K
7	R3	E-00105-0282	Resistor 1/4W 5% 33K
8	R4	E-00105-0257	Resistor 1/4W 5% 3.9K
9	R5, R6, R9, R17, R19, R20, R23, R25, R26, R27, R30	E-00105-0185	Resistor 1/4W 5% 10K
10	R10	E-00105-0248	Resistor 1/4W 5% 150K
11	R11, R12, R14	E-00105-0285	Resistor 1/4W 5% 1M
12	R13	E-00105-0284	Resistor 1/4W 5% 470K
13	R15	E-00105-0279	Resistor 1/4W 5% 360
14	R16	E-00105-0280	Resistor 1/4W 5% 470
15	R18	E-00105-0278	Resistor 1/4W 5% 2.7
16	R8	E-00105-0287	Resistor 1/4W 5% 2.2K
17	R21	E-00105-0246	Resistor 1/4W 5% 110K
18	R22	E-00105-0286	Resistor 1W 4.7K
19	R24	E-00105-0223	Resistor 1/4W 5% 82K
20	R7	E-00105-0289	Resistor 1/4W 5% 1.1K
21	R29	E-00105-0230	Resistor 1/4W 5% 1K
22	R36	E-00104-0096	Resistor 5W, 10% 75Ω
23		E-00599-0015	Resist. Var. 91B, 10K
24	C1, C10	E-00586-0068	Cap., Disc. 100PF 1000V
25	C3, C14, C15, C18	E-00586-0065	Cap., Disc. .01MFD 500V
26	C7	E-00586-0087	Cap., Disc. .02MFD 500V
27	C19, C2, C5, C9, C16, C21	E-00586-0088	Cap., Disc. .05MFD 16V
28	C4, C12	E-00586-0089	Cap., Disc. .1MFD 25V
29	C8, C11	E-00586-0090	Cap., Elect. 1MFD 25V
30	C6	E-00586-0063	Cap., Elect. 2MFD 25V
31	C13	E-00586-0091	Cap., Elect. 100MFD 25V
32	C17	E-00586-0092	Cap., Elect. 100MFD 100V
33	Q1 (TIP 29)	E-00585-0043	Transistor NPN
34	Q2, Q3 (2N 3904)	E-00585-0031	Transistor NPN
35	CR1, CR2 (1N 4148)	E-00587-0014	Diode
36	CR3 (1N 4004)	E-00587-0015	Diode
37	CR4 (1N 5243)	E-00598-0011	Diode, Zener
38	U1, U8 (MC 14049B)	E-00620-0033	Hex Inverter (I.C.)
39	U4, U5 (MC 14526B)	E-00620-0044	Programmable 4 Bit Counter
40	U2 (MC 14042B)	E-00620-0045	Quad. Latch
41	U7 (555)	E-00620-0004	Timer I.C.
42	U9 (LM 741)	E-00620-0047	Operational Amp.
43	U10 (LM 380N)	E-00620-0048	Audio Amplifier
44	U11 (86 L93)	E-00620-0046	4 Bit Binary
45	C20	E-00586-0064	Cap., Disc. .002
46	A8 (see note 2)	AS-2518-32	PWB Module Less Program Memory U3

NOTE 1:

When ordering specify name of game.

NOTE 2:

Order replacement memory chip U3 specifying name of game and part no. stamped on chip.

GENERAL

To select a sound, the Sound module decodes the address signals received from the MPU module via the five address lines A, B, C, D and E (J1, pins 1, 2, 3, 4, and 12). The address is read and the sound is started only if a sound interrupt is also received from the MPU. This interrupt is caused by the low to high transition of the solenoid bank select signal (J1, pin 8).

The troubleshooting procedure, outlined herein, assumes that the MPU module is functional and that the above signals are generated. In general, since four of the address lines (A, B, C and D) and the solenoid bank select are shared with the Solenoid Driver module A3, faulty operation of these signals may also result in solenoid drive problems. In this case, the Sound module should be disconnected and if the fault persists, reference should be made to the MPU and/or Solenoid Driver Troubleshooting Procedures. If the fault clears with the Sound module disconnected, the cause of the address or solenoid bank select signal degeneration should be determined and corrected at the Sound module. If that signal continuity exists between MPU and Sound module connectors. For a more complete test, A1D may be used. Also, SW1 test switch on the Sound module may be used to start a test sound independent of MPU signals. This feature permits an overall check of the Sound module operation and may be used to simulate playfield switch activity. (NOTE: Early sound program versions *do not* provide this capability.)

TEST AND MEASUREMENT TECHNIQUES

Unless otherwise specified, all voltage measurements indicated on the schematic or called for in the troubleshooting procedure are made with reference to the ground test point TP3. Use of a Simpson 250 VOM, or equivalent, is assumed.

1. AC and AUDIO VOLTAGE MEASUREMENTS.

AC and audio voltage measurements require the addition of a 0.1 ufd (25WVDC min.) capacitor in series with the test lead connected to the signal (+) terminal of the voltmeter. This is necessary to block any DC voltage which may be present. Failure to observe this technique will result in misleading AC readings when using Simpson 250 VOM. (Other voltmeter models may have a built-in DC blocking capacitor or provide a special terminal for measuring AC signals in presence of DC. Reference should be made to manufacturer's recommendations, if use of a voltmeter other than Simpson 250 is necessary.)

2. SOUND-IN-PROGRESS.

Some measurements indicated on the schematic, or called for in the test procedure, are to be made with or without sound in progress. When sound is heard, the term is self-explanatory. When, due to a malfunction, sound is not heard, "with sound" or "sound-in-progress" measurements should be performed under test conditions where a sound would normally be heard. (In practice there are several ways to achieve this. The game may be brought up to play and a play field switch, that should produce a sound, activated just before the measurement is to be taken. If the sound options switch is set such that no background sound is produced, both the "with" and "without" sound measurements can be readily obtained in this way. Another way is to put the game in sound self-test mode, in which case the sound interrupt triggering a test sound will occur automatically.) Similarly, measurements with no sound should be made under test conditions where no sound (including background) would normally be produced.

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-I

REPAIR LEVEL: POWER SUPPLY RELATED FAILURES

CAUSE	PROCEDURE
-------	-----------

SYMPTOM IA: No Sound or Distorted Sound. TP2 (+5VDC) Voltage Incorrect.	
A) Open +5V Line	Measure +5 \pm .25VDC at TP2. If absent, measure +5VDC at A3-TP1 of Solenoid Driver/Voltage Regulator module. If present at A3-TP1, locate and repair open between connector and TP2 on the Sound module.
B) Defective +5V Regulator Circuit	If incorrect at A3-TP1, refer to Solenoid Driver/Voltage Regulator Trouble-shooting Procedures.

SYMPTOM IB: No Sound or Distorted Sound. TP1 (+11.9 \pm 2.4VDC) Voltage Incorrect.	
A) Open +12V Line or Open CR1	Measure +11.9 \pm 2.5VDC at TP1. If absent, measure +11.9VDC at A3-TP5 of Solenoid Driver/Voltage Regulator module. If present at A3-TP5, locate and repair open between connector and TP1 on the sound module. Check also for open CR1. If incorrect at A3-TP5, refer to Solenoid Driver/Voltage Regulator Trouble-shooting Procedures.

SYMPTOM IC: Distorted Sound. TP1 (0.1VAC Max.) voltage excessively high.

A) Open C15 or Shorted CR1	Measure 0 to 0.1 VAC at TP1. If excessively high, measure 0 to 0.5VAC at Ja-10. If correct at J1-10, check for open C15 or shorted CR1 and replace if defective. Check also for open +5 unreg. return line to J1-15. If problem persists, check for open C6. Replace if defective.
B) Open C6	
C) Defective A3-C23	If AC ripple at J1-10 is excessively high, check for faulty A3-C23 filter capacitor on Solenoid Driver/Voltage Regulator module. Replace if defective.

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-II

REPAIR LEVEL: AUDIO CIRCUITRY RELATED FAILURES

CAUSE	PROCEDURE
-------	-----------

SYMPTOM IIA: No Sound or Intermittent Sound.	
A) Defective Loudspeaker	With volume control set to maximum (RT1 all the way CW) measure 0VDC, 2 to 6VAC audio signal (with sound in progress) at J2-2. If audio is correct, check for continuity of loudspeaker connections from J2-1 and J2-2. Repair if defective, else replace loudspeaker.
B) Shorted or leaky C8	If audio is absent, check for shorted loudspeaker. Replace if defective. If voltage at J2-2 is not 0VDC, replace C8. (NOTE: With loudspeaker open or disconnected, the DC voltage will float to about +1.5VDC.)
C) Open C8	If audio is not present at J2-2, measure 2 to 6 VAC audio signal at U9-4. If correct, replace C8.

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-II

REPAIR LEVEL: AUDIO CIRCUITRY RELATED FAILURES

CAUSE	PROCEDURE
-------	-----------

SYMPTOM IIA: No Sound or Intermittent Sound

D) Defective U9, C5 or C7	With no sound in progress, measure $+6 \pm 1\text{VDC}$ at U9-4. If correct, check for shorted or leaky C5 or C7. If not found defective, replace U9.
---------------------------	---

E) Defective RT1, C5, or R6	If audio is not present at U9-1, measure $1.5 \pm .5\text{VAC}$ at U8-4 with sound in progress. If correct, check for open RT1, C5 or R6. Replace as necessary.
-----------------------------	---

F) Defective U8 and associated components	If audio is not present at U8-4, measure $.35 \pm 1\text{VAC}$ at TP6 with sound in progress. If audio is present at TP6, replace U8. Also check for defective associated components and replace as necessary. If audio is not present at TP6, refer to A8-III.
---	---

SYMPTOM IIB: Sound is present, but has muffled quality due to excessive high frequency attenuation.

A) Shorted Q1	Check for shorted Q1 and replace if necessary.
---------------	--

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-III

REPAIR LEVEL: MICROPROCESSOR AND MEMORY RELATED FAILURES

CAUSE	PROCEDURE
-------	-----------

SYMPTOM IIIA: No Sound or Abnormal Pitch

A) Defective Y1, C18, C19, U3 or U1	Measure $+2.5 \pm .2\text{VDC}$ at TP5. If incorrect, replace U3, U1, Y1, C18 or C19 as necessary.
-------------------------------------	--

SYMPTOM IIIB: No Sound.

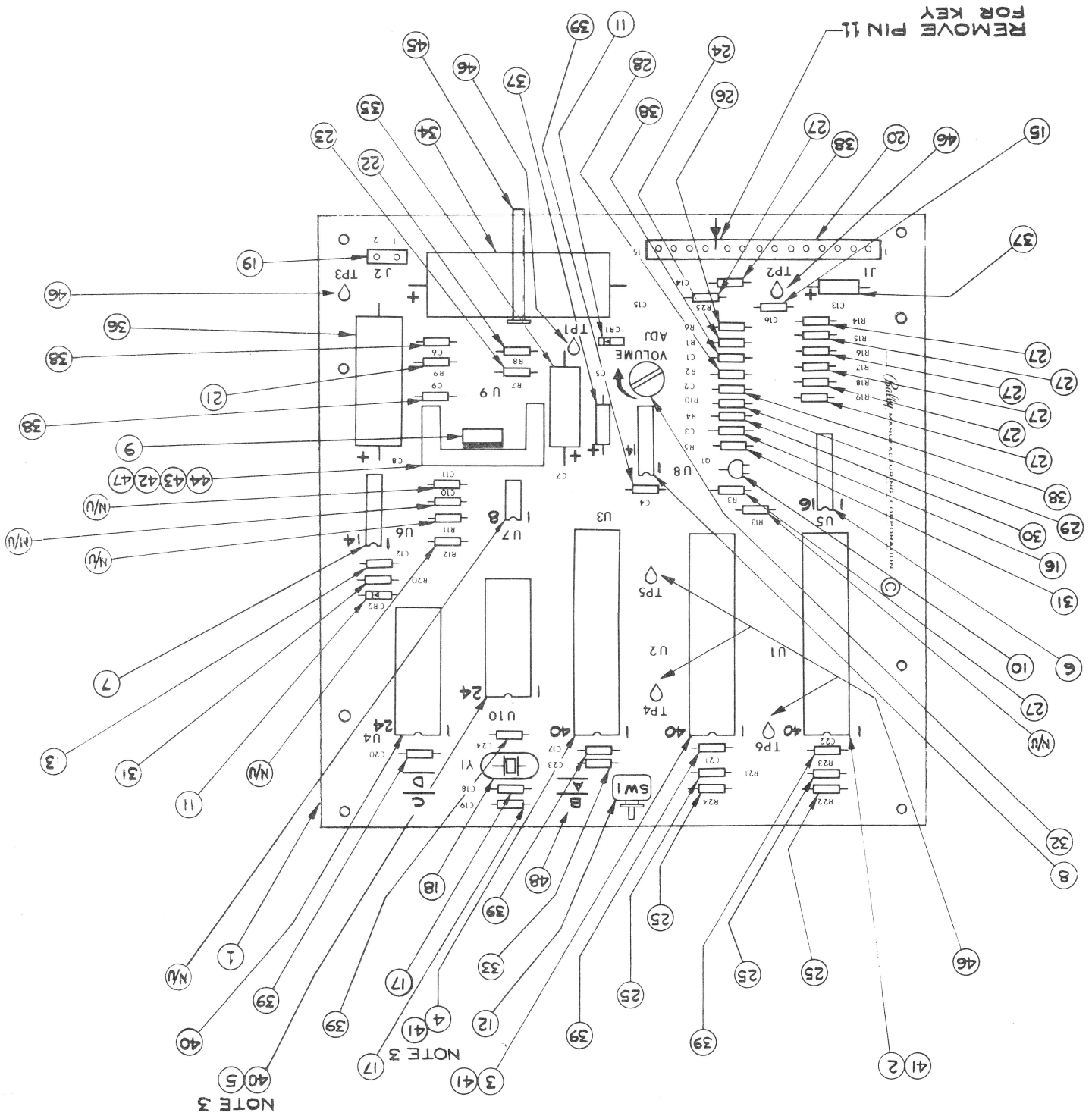
A) Defective U6	Measure 0VDC at U6-3. Momentarily turn off game power and then turn it on again. Note that the meter kicks positive at the time the game is turned on. If incorrect, replace U6 or associated reset circuit components (C12, R20, CR2).
-----------------	---

B) Defective U1 or U2	Measure $+2.5 \pm 1\text{VDC}$ at TP4 when sound is in progress; 0VDC with no sound.
-----------------------	--

C) Defective U4, U10, U3 or U6	If correct, measure audio signal at TP6 (See A8II-F). If incorrect at TP6, refer to section A8II. If audio is not present at TP6, but TP4 measurements are correct, replace U1. If problem is not corrected replace U2. If TP4 voltage is not 0 with no sound, momentarily turn off the game power and then turn it on again. If TP4 voltage does not go to 0 after about 8 seconds from power-on, replace U4 or U10. If the problem is not corrected or repeats, check for address/data bus shorts or opens and repair as necessary.
--------------------------------	---

DIAGNOSTIC TABLE: COMPUTER SOUND MODULE A8-III	
REPAIR LEVEL:	
CAUSE	PROCEDURE
SYMPTOM IIIB: No Sound.	
D) Interrupt line fault	<p>If none found, replace U3.</p> <p>Check also for defective U6 and replace if necessary.</p> <p>If voltage at TP4 measures 0VDC with sound in progress, measure +3.5 ± 0.5VDC at U2-40 (with game in sound self-test mode).</p> <p>If incorrect, measure +4 ± 0.5VDC at A4J4-10 of MPU module.</p> <p>If correct at MPU connector, repair interrupt line to J1-8 of the sound module.</p> <p>If incorrect at A4J4-10, check for possible short to ground. If none found, refer to MPU troubleshooting procedure.</p>
E) Defective U2 or U3	<p>If interrupt line checks OK, replace U2 and/or U3.</p>

AS-2518-51 SOUND MODULE



A8: SOUND MODULE COMPONENT PARTS LIST

ITEM	REFERENCE	PART NO.	DESCRIPTION
1	A8 (see note 1)	E-3022-1	PWB Module Complete
2	U1	E-620-124	Sound Chip AY-3-8910
3	U2	E-620-29	PIA, 6820/21
4	U3	E-620-125 (E620-128)	CPU, 6808 (6802 Note 3)
5	U10	E-620-30	Ram, 6810 (Note 3)
6	U5	E-620-33	Hex Inverter 4049B
7	U6	E-620-5	Quad 2 Input 4011B
8	U8	E-620-126	Amp, LM3900
9	U9	E-620-127	Power Amp, TDA 2002
10	Q1	E-585-31	Transistor, 2N3904
11	CR1, 2	E-587-6	Diode, 1N4004
12	SW1	E-658-1	Switch
13	C12	E-586-118	Cap. .2MF±20% Y5P, 16 V.
15	C16	E-586-83	Cap. 470 PF 50 V.
16	C3	E-586-120	Cap. 68 PF ±20% 1K
17	C18, 19	E-586-121	Cap. 27 PF ±20% 1K
18	Y1	E-744-5	Crystal, 3.579545 MHZ
19	J2	E-736-2	Connector, Water, 2 Pin KK156
20	J1	E-736-15	Connector, Water, 15 Pin KK156
21	R9	E-105-196	Resistor, 1 Ohm, 1/4 W, 5%
22	R8	E-105-211	Resistor, 2.2 Ohm, 1/4 W, 5%
23	R7	E-105-303	Resistor, 220 Ohm, 1/4 W, 5%
24	R1	E-105-230	Resistor, 1 K, 1/4 W, 5%
25	R21, 22, 23, 24	E-105-238	Resistor, 3.3K. Ohm, 1/4 W, 5%
26	R6	E-105-239	Resistor, 4.7K., 1/4 W, 5%
27	R3, 14, 15, 16,	E-105-185	Resistor, 10K., 1/4 W, 5%
28	R2	E-105-245	Resistor, 30K., 1/4 W, 5%
29	R10	E-105-252	Resistor, 180K., 1/4 W, 5%
30	R4	E-105-225	Resistor, 200K., 1/4 W, 5%
31	R5, 20	E-105-285	Resistor, 1M, 1/4 W, 5%
32	RT1	E-599-16	Potentiometer 1K
33	C23	E-586-122	Cap. .001±20% 25F
34	C15	E-586-123	Cap. 4700 MF @ 25 V.
35	C7	E-586-124	Cap. 470 MF @ 6.3 V
36	C8	E-586-125	Cap. 220 MF @ 25 V.
37	C5, 13	E-586-90	Cap. 1 MF @ 50 V.
38	C9, 1, 14, 6, 2	E-586-89	Cap. .1 MF
39	C4, 22, 17, 21,	E-586-85	Cap. .01 MF
40	XU10, XU4	E-712	Socket, 24 Pin
41	XU1, XU2, XU3	E-712-1	Socket, 40 Pin
42	Used with 43	LSPR-00632-1106	Bolt, 6 x 32 x 3/8
43	Used with 42	N-00632-2112	Nut, 6 x 32
44	H.S for U9	E-682-8	Heat Sink, 6030BTT
45	Used with C15	E-647-5	Ty Rap
46	TP1, 2, 3, 4, 5, 6	P-5399	Test Point
47	Use with 44, 9	M-1834	Thermal Grease
48	Jumper, B	W-1211c	22 AWG Wire, Solid Tinned Schematic

NOTE 1: When ordering specify name of game.

NOTE 2: Order replacement memory chip U4 specifying name of game and part no. stamped on chip.

NOTE 3: When using item 4, 6808 you must use item 5, 6810 and the "B" jumper. When item, 6802 is available delete item 5 and use "A" jumper.

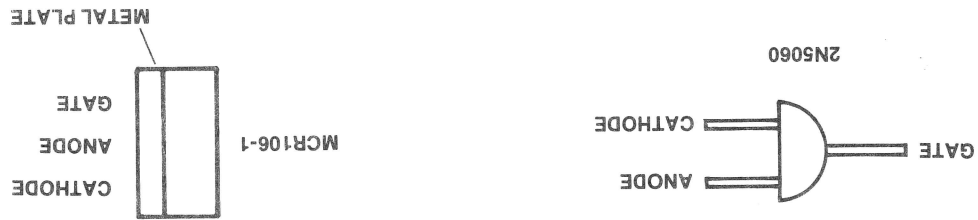
518	Sound PCB (Does not include Memory Chips)
503	MPU Module, A4 (Does not include Memory Chips U1-U6)
493	Display Driver Module, A1
492	Solenoid Driver/Voltage Regulator Module, A3
490	Power Transformer Module, A2

KIT # PARTS KIT FOR REPAIR OF MODULE:

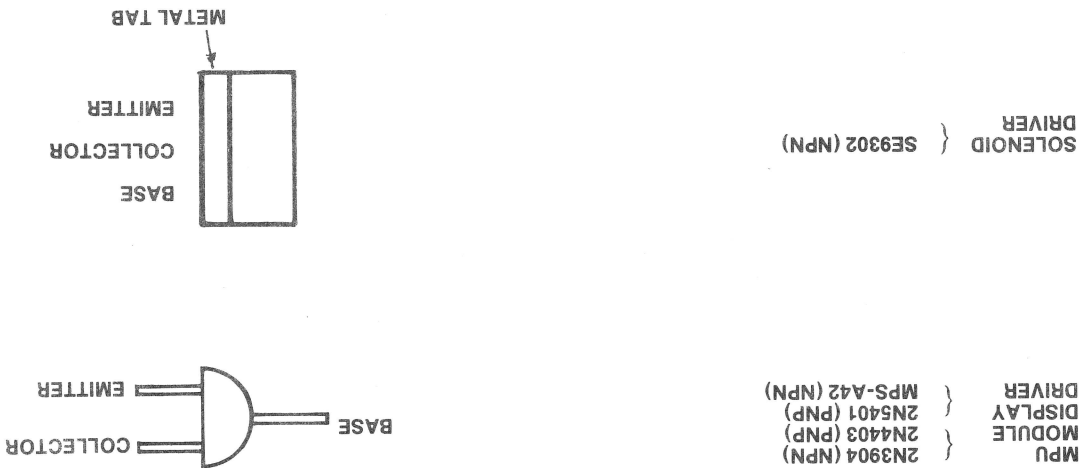
The following is a list of module repair parts kits recommended for doing component replacement to each of the five module types. Each of the kits can be ordered from your Bally Distributor.

MODULE REPAIR SPARE PARTS KITS

FIGURE IV SEMICONDUCTOR LEAD CONNECTIONS



**SILICON-CONTROLLED RECTIFIER LEAD CONNECTIONS
LAMP DRIVER MODULE**



TRANSISTOR LEAD CONNECTIONS